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SALE AREA BETTERMENT AND STAND IMPROVEMENT HANDBOOK
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U. S. FOREST SERVICE
DEPARTMENT OF AGRICULTURE

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SALE AREA BETTERMENT AND STAND IMPROVEMENT HANDBOOK

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I. INTRODUCTION

These instructions describe technical specifications and policies for performance of work with sale area betterment deposits as provided for by the Knutson-Vandenberg Act and timber stand improvement operations from any source including free use, administrative use, contributed time, and appropriations.

1. These instructions are only a guide; no general instructions can take the place of a forester's skill in determining the measures necessary to treat a particular stand.

2. They are not intended to take the place of preliminary and final plans necessary for carrying out individual projects.

3. Stand improvement work may also be done for recreational or other purposes, but these instructions apply only to measures intended to improve timber production.

Limitations of the K-V Act

Although the K-V Act provides that deposits are "available until expended," administrative considerations require that work be completed at the earliest practicable date. Sale area betterment work should be completed within 5 years after closing of sale, except that in approved white pine blister rust control units work should be completed within 10 years after closing of sale.

The foregoing time limit policy in combination with provision of the K-V Act that work be confined to "the national forest land cut over by the purchaser" to a large extent limits work to site preparation, disposal or treatment of undesirable trees and brush, planting, cleaning and pruning.

The protection of established reproduction from insects, diseases, rodents, fire, stock, game or other damage is not provided for by the K-V Act, except that blister rust control measures are permissible within approved control units. While the K-V Act does not authorize protection against disease, etc., it specifically authorizes use of the funds for "cutting, destroying, or otherwise removing undesirable trees or other growth on the national forest land cut over by the purchaser, in order to improve the future stand of timber." The words "other growth" would cover plants other than trees and include any shrubbery on the area the removal of which will improve the future timber stand. So long as the removal is for the improvement of future stands of timber it is permissible, whether improvement results from elimination of disease host plants, shade that retards young tree growth, root competition, or other condition incompatible with best development of the future stand. The undesirable plants authorized to be removed are plants on the area cut over by the purchaser; the authority for such use of K-V funds does not extend to plants on adjoining or nearby areas the removal of which may be desirable for best results.

K-V funds should not be held over for plantation release or any work of a follow-up nature, except for treatments that are logically done in two or more operations. For example, mistletoe eradication may be more effective if done in two or more operations 2 or 3 years apart. When work is to be in stages, it should be so stated in the plan. K-V funds are not available for post-operative work, such as replanting, planting examinations, cut-over area studies, etc.

K-V funds should not be used to dispose of slash or other fire hazards resulting from the timber sale operation. Snags should not be felled with K-V funds as such work is not a silvicultural treatment. Slash created by the logging operation and snags should be taken care of by the purchaser or with cooperative brush funds under authority of the Act of 1916.

Approved K-V Act Practices

Field examination of the cut-over area for the purpose of improving preliminary plan for sale area betterment work may be financed with K-V funds.

Examples of some of the improved techniques used in the regeneration of stands following commercial cuttings for which K-V funds may be used are:

1. Preparation of the seedbed by scarification, prescribed burning or otherwise. On certain sites in some types the area can be disked following cutting and cone bearing slash scattered over the disked area. In some types mineral soil is necessary for germination of seed. Prescribed burning in advance of seed fall in a good seed year is suggested.

2. Ground or site preparation by prescribed burning, scalping, disking, furrowing or other means to reduce the vegetative competition, such as the application of herbicides or the cutting of woody plant growth from around the location where the trees are to be or have been planted, are frequently measures necessary to the most economical establishment of planted trees.

3. Control of rodents immediately prior to or at the time of planting may be necessary to establishment.

4. Control of ruminants when absolutely essential to the establishment of regeneration. This may, in some cases, require the fencing of an area.

S.A.B. Versus T.S.I.

The foregoing high lights about the K-V Act will serve to establish the fact that there is distinct difference between sale area betterment and timber stand improvement. The key point in preparing plans and making on-the-ground decisions is S.A.B. versus T.S.I.

On first thought, it might appear that the limitations associated with S.A.B. tend to restrict the resource manager in carrying out long-time objectives, but keep in mind that in several types we are working on 30-year or other rather short cutting cycles. Furthermore, administrative use sales within or adjacent to commercial sales provide plenty of possibilities for improvement of stands.

In April 1948, page 9 of form 202, Timber Sale Agreement, was revised so as to include the following clause:

> The United States reserves the right to sell from the sale area during the life of this agreement any material not covered by the terms of this agreement; Provided, That the removal of such material shall not, in the judgment of the Forest Officer in charge, interfere with the operations of the purchaser.

Additional information on administrative procedure, policy covering rate per M, maximum collection per acre for S.A.B. by zones, splitting of appraised value into K-V deposits and stumpage, etc., will be contained in Timber Management section of the Forest Service Manual and Region One supplements.

In planning and administration of S.A.B. keep in mind the fact that there are a lot of fine points to growing crops of timber and also fiscal controls associated with a forest officer's privilege of diverting a portion of the revenue expected by the people of our Nation under authorization granted by the K-V Act.

The Timber Production Job

Need for stand improvement generally is caused by one of the seven following silvicultural conditions:

1. A high proportion of less valuable species in young reproduction stands.
2. Diseased, badly formed, mistletoe-infected, porcupine-damaged or otherwise defective or undesirable trees or other growth present that impede or prevent development of younger or better quality trees.
3. Excessive density of second-growth stands.
4. Excessive limbiness of pole-size trees.
5. Lack of desirable reproduction.
6. Occurrence of defective, unmerchantable stands.
7. Occurrence of low-vigor trees susceptible to bark beetle attack.

Correction of these conditions involves:

1. Site preparation.
2. Cleanings.
3. Liberation cuttings, girdling and poisoning.
4. Thinnings and improvement cuttings.
5. Pruning crop trees.
6. Fill-in planting in understocked stands.
7. Prescribed burning followed by planting.
8. Eradication of undesirable plants which will retard or preclude the establishment of desired reproduction such as dense patches of brush or presence of ribes in the white pine type.

Objective

1. The objective of stand improvement is to restore or improve productiveness.
2. The work necessarily will be governed by conditions on the ground. Cut-over areas should be given such silvicultural treatments as are desirable and permissible under the K-V Act.
3. A preliminary sale area betterment plan must be made a part of appraisal reports for each sale in order to determine the amount per unit of volume to collect.

Benefits

The benefits of S.A.B. and T.S.I. work can be summarized as follows:

1. Increasing proportion of more valuable species.

2. Regenerating the stand promptly.

3. Producing trees of higher average quality by concentrating growth on high-quality stems.

4. Producing trees of larger average diameter through concentrating the growth capacity of the site on fewer and faster growing stems.

5. Increasing volume growth through better spacing and reduced mortality.

6. Decreasing proportion of cull material.

7. Establishment of residual stands resistant to bark beetle attack.

II. CONSIDERATIONS AND PRACTICES WHICH APPLY TO ALL TYPES

Timber management is a continuing process. The establishment of a stand and the final harvest of that stand are only two phases of management. Just as important is the care of the stand between establishment and harvest.

One of the major functions is to maintain a full and vigorous growing stock of desirable species. The importance of maintaining a full growing stock cannot be overemphasized. In this way we can make the soil produce its maximum in timber yields and values.

K-V funds will not be used when the desired silvicultural benefits can be obtained satisfactorily by means of action under regular timber disposal procedures, administrative use as per Regulation S-25, and free use. Regular sales procedures should always be looked upon as the primary and desired method of doing stand improvement. They should always be fully explored before resorting to sale area betterment cooperative deposits to do the job.

Improvement of timber crops requires close supervision. If the work is not supervised carefully, a lot of useless work will result.

The tendency is to do too much - to "polish" unnecessarily. This tendency must be guarded against constantly to avoid waste of manpower. Crews must be educated to cut corners, to get the maximum results from a minimum of expenditure. This is one of the biggest problems we face. We must make sure that we buy the most with each dollar expended.

Financial

The K-V Act limits collections on an average basis to the average cost of planting other comparable national forest land. (Refer to R-1 supplement to Timber Management section of Forest Service Manual for current rates.)

In the selection of stand for treatment and in the intensity of different classes of work, the aim should always be to obtain the greatest total return, though not necessarily an early return for the money expended. Evaluation is admittedly difficult, but unless a rational attempt is made to do so, relative priorities between different types of work and between different projects cannot be intelligently determined.

This process of evaluation can be demonstrated as follows: Suppose we estimate that a cleaning operation should result in an increase in stand value per acre at time of final harvest as shown in following table.

Estimate of the Value Resulting From Cleaning a Stand in the Western White Pine Type

	Merchantable volume per acre all species (M board feet)	Volume at maturity		Stumpage value per M board foot		Total value		
		Western white pine	Other species	Western white pine	Other species	Western white pine	Other species	Total
Without cleaning	40	35%	65%	$10	$5	$140	$130	$270
With cleaning	40	65%	35%	10	5	260	70	330
Effect of cleaning	0	+30%	-30%	0	0	+120	-60	+60

Estimated increase in total value of $60 per acre due to treatment shown in table gives a specific value against which to compare costs of the stand improvement job. By this method one type of stand improvement work can be compared to others and one project weighed against another as an indicator as to whether the work contemplated will "pay out."

Employment Stabilization

Stand treatment on the national forests offers a vast reservoir of work for the stabilizing of employment.

Sale area betterment work can aid in stabilizing employment of key seasonal personnel by extending their periods of employment. However, discretion must be used in taking advantage of K-V funds to extend employment of seasonal workers. Winter climatic conditions such as snow, cold, and wet weather cut down the efficiency of the work; and they may lead to excessive costs. Excessive costs cannot be countenanced. In other words, if work cannot be done efficiently "off season," it should be planned for and accomplished "in season."

Coordination With Other Land Uses

Wildlife needs will be determined by wildlife technicians and coordinated with timber use objectives. Openings such as small meadows, mill settings, and skid roads might be beneficial to wildlife. In major-size plantations game openings might be permitted. Trees along streams might protect the fish habitat.

Water resource and recreation must be kept in mind. Forest Service Manual, NF-C2-8, page 1, includes a discussion of the means by which grazing can be correlated with timber use.

Area Selection

Only areas dedicated to timber production will be selected for treatment. Treatment of recreation and roadside areas as such are not authorized sale area betterment work.

Accessible areas will usually receive priority over inaccessible areas. However, this can be applied only so far. The hope in timber growing on many relatively inaccessible areas is to grow quality products which can bear the high transportation and logging costs caused by their inaccessibility.

Stand improvement operations should be confined to areas which can be expected to yield quantity or quality. Areas of better site quality will usually receive first consideration.

Significance of Soil

As silvicultural practices become more intensive, there comes a need for knowledge of one of the most important factors of timber production - the forest soil. An understanding of some of the characteristics of the soil profile is essential. Podsol type of soil develops under a dense forest canopy with its characteristic low temperature and slow decomposition of organic matter resulting in varying accumulation of raw humus. During periods of heavy precipitation the easily soluble salts, especially nitrates, leach out of the surface soil and produce acid conditions. Soil reaction, termed pH, is used as a numerical expression of acidity or alkalinity. Rating of "7" represents neutral reaction, decreasing values indicate a rise in acidity. Most coniferous forest soils have a pH ranging between 5.5 to 6.5. Excessive alkalinity precludes any forest growth. Hemlock thrives in soils with pH ranging as low as 4.0, or very strongly acid. Too high acidity results in impairment of microbiological and physical properties of soil. Another factor worthy of consideration is the compacting of forest soils; overmature stands on good sites result in a weight of from 175 to 200 tons per acre. In the case of flat-rooted species such as hemlock and grand fir, compacting of subsoil might be a factor in survival of young growth after it attains sapling size. Foresters interested in soil and other ecological factors should study "Foundations of Silviculture Upon an Ecological Basis" by James W. Toumey and Clarence F. Korstian.

Tree Selection

In a given stand, certain species and certain individual trees are more desirable than others. Promoting the development of desirable species and individuals is the general objective of tree selection. The relative desirability of the various native species is listed in the discussions for individual types.

Between two trees of the same species, the best tree from the standpoint of form and vigor will usually be reserved.

At times the best species and the tree of best form and vigor cannot be reserved because of spacing requirements.

No more trees should be cut than necessary to release selected trees.

Crop-Tree Principle

The primary consideration in most stand improvement and S.A.B. work is to think in terms of the trees which will make up intermediate and final crops.

The trees selected as "crop trees" should receive the major attention in stand improvement.

In general about twice as many crop trees as will form the final crop should be reserved to allow for mortality and injury.

III. DEFINITIONS OF STAND IMPROVEMENT MEASURES

Definitions for stand improvement measures, as given below, are taken from "Forest Terminology," published by the Society of American Foresters. Definitions include some measures which strictly are not stand improvement but that fall within the authority for sale area betterment. The following terms should be used correctly. Loose and inaccurate use of words such as "thinning" cause confusion.

Cleaning

A cutting made in a young stand, not past the sapling stage, for the purpose of freeing trees from other individuals of similar age but of less desirable species or form which are overtopping them, or likely to overtop. Syn. - disengagement cutting, weeding.

Liberation Cutting

A cutting made in a young stand, not past the sapling stage, for the purpose of freeing the young trees from older individuals that are overtopping them.

Improvement Cutting

A cutting made in a stand past the sapling stage for the purpose of improving its composition and character, by removing trees of less desirable species, form, and condition in the main crown canopy.

Intermediate Cutting

Cuttings made in a stand between the time of its formation and its major harvest and reproduction. Included are cleaning, liberation cutting, thinning, improvement cutting, salvage cutting, and sanitation cutting.

Salvage Cutting

A cutting made to remove trees killed or injured by fire, insects, fungi, or other harmful agencies, for the purpose of utilizing merchantable material before it becomes worthless.

Sanitation Cutting

A cutting made to remove trees killed or injured by fire, insects, fungi, or other harmful agencies (and sometimes trees susceptible to such injuries), for the purpose of preventing the spread of insects or disease.

Thinning

A cutting made in an immature stand for the purpose of increasing the rate of growth or improving the form of the trees that remain and increasing the total production of the stand. Three distinct types of thinnings are recognized, each based on a different principle in selecting trees to be removed. These are low thinning (thinning from below), crown thinning, and selection thinning.

Crown Thinning

Cutting is made principally in the upper crown classes by the removal of codominant and dominant trees that are competing strongly with the most promising individuals of these classes. Cutting in the lower crown classes is directed

toward removing trees that will die and be wasted before the next cutting and is carried on only if such trees have a positive net conversion value.

Low Thinning

Low thinning anticipates natural thinning of a stand through competition, by working upward from overtopped to dominant trees, in five recognized intensities of cutting, as follows:

Grade A - Light. Removes the poorest overtopped trees.

Grade B - Moderate. Removes all overtopped trees and the poorer intermediate trees.

Grade C - Heavy. Removes all overtopped and intermediate trees and often a few codominant trees.

Grade D - Very Heavy. Removes all overtopped and intermediate trees and many to most of the codominant trees.

Accretion Cutting. A cutting heavier than the D grade, removing all the codominant and a few dominant trees to obtain exceptionally rapid diameter growth on reserved trees.

Selection Thinning

The largest dominant trees and the poorest overtopped trees if possessing a positive net conversion value are cut, the former to remove potential wolf trees of relatively low value and the latter to utilize these trees before they become a total loss. Syn. - Borggreve thinning.

Pruning

Artificial

Removal by artificial means of live or dead branches from standing trees.

Natural

The natural death and fall of branches on standing trees resulting from such causes as deficiency of light, decay, snow, and ice. Syn. - self-pruning.

Burning, Prescribed

The application of fire to land under such conditions of weather, soil moisture, time of day, and other factors as presumably will result in the intensity of heat and spread required to accomplish specific silvicultural, wildlife, grazing, or fire-hazard reduction purposes.

High Lights of Cuttings Using K-V Funds

Type of cutting	Size of items	Primary purpose
Cleaning	Seedlings and saplings	Improve species composition
Liberation	" " "	Release from larger stems
Improvement	Poles and larger	Improve species composition
Thinning	" " "	Increase rate of growth
Pruning	Small poles	High-grade lumber

IV. APPLICATION OF STAND IMPROVEMENT MEASURES

Cleaning

Cleaning should not be delayed too long. Trees in stands to be cleaned should not average more than 2 inches in diameter. This diameter is approximately the maximum size that can be treated by hand nippers, brush hooks, hatchets, and other light tools. In larger stands, cutting requires more labor and heavier tools, brush disposal is likely to be necessary, and different methods are required.

Stands should not be cleaned unless the stand can be materially improved. For example, cleaning in a stand already largely dominated by a desirable species is rarely justified because the stand will in all probability yield high value at maturity without treatment. An exception is the overdense stand which needs a reduction in number of stems if the stand is to develop properly. In general, stands containing more than 5,000 trees per acre more than 1 foot in height are overstocked and will be benefited by a reduction in number of stems.

To be most effective, cleanings should be delayed until dominance is well established, at which time the cleaning should be heavy.

Stands selected for treatment should contain sufficient numbers of the desired species so that when given proper release they can be expected to form an important part of the final stand. Cleanings in poorly stocked stands are rarely desirable or necessary unless further reproduction can be expected, as the cleaning is likely to reduce the stocking below that necessary to maintain site protection and to prevent the development of bushy, limby trees.

The first requisite to intelligent tree selection is an understanding of the relative development of associated species in the type.

In the selection of trees to be cut and to be left, it should again be stressed that the major purpose of this work is to increase the proportion of trees of desirable species in the stands by releasing the better trees from excessive competition by other species. It is neither necessary nor desirable to attempt to eliminate all but the selected trees and the mechanical cutting of everything but one or two species must be avoided. The general guides as to relative desirability of species, as shown elsewhere in this handbook, should not be slavishly observed. For instance, grand fir in the southern part of the white pine type is a more desirable species than in the northern part. On the fringes of the white pine type, ponderosa pine does better and should receive more consideration in selection of species. Deciduous shrubs and trees seldom offer serious competition to establish reproduction in the western white pine type. Their presence is usually beneficial as a temporary ground cover under which coniferous reproduction develops readily. Where deciduous species do cause important competition, they should be cut the same as coniferous species.

Marking, organization of work and tools for cleanings are discussed under appropriate headings in other parts of the handbook.

Ordinarily, trees should be cut to within 18 inches of the ground. The exact height is immaterial; the essential objective is to cut low enough to remove competition effectively.

Cleanings can be made at any time of the year except when appreciable amounts of snow cover the ground. Excessive snow makes proper tree selection difficult and work inefficient. As cleanings can be made during most of the year they can be used effectively as a fill-in job.

Cleanings usually require from 1 to 4 man-days per acre, with the average job requiring from 1 to 2 man-days.

Liberation Cutting

Liberation cuttings, which remove sapling-size trees of larger size to free smaller ones of more desirable species, call for some discretion in application. One good general guide that may be found useful is to remove only trees that are not more than twice as large in diameter as the trees which are being favored. Another rule, where there is more work available than money to accomplish it, is to cut only trees that can be removed with a single ax stroke. This will help to attain liberation of the maximum number of trees for the money. These rules are suggested only as guides worth considering. There may be others more applicable in certain situations.

A rule that should be applied generally is to leave overtopping trees that are likely to become merchantable within the next cutting cycle.

Improvement Cutting

Improvement cuttings are made in stands past the sapling stage for the purpose of improving its composition and character, by removing trees of less desirable species, form, and condition in the main crown canopy. Improvement cuttings are similar to cleanings in character except that they are made in older stands. In stands managed from the juvenile stage, cleanings made at the proper time will eliminate most of the need for improvement cuttings at a later date.

The cost of making improvement cuttings is usually prohibitive unless the products of cutting can be utilized. Hence, the general policy will be to depend on administrative use sales procedure to make improvement cuttings at such time as the products of cutting become merchantable. An exception to this policy will be pole stands within sale area boundaries which have trees seriously defective by fungi or trees which are unmerchantable because of excessive crook, limbiness, or other cause. In special cases of this type, K-V funds may be used to rid the stand of these trees by poisoning or girdling.

Since K-V work in improvement cuttings will consist of girdling and poisoning, dead standing trees will result. Care must be taken not to create a fire hazard greater than M-M. Not more than 50 trees per acre should be killed within a 5-year period.

Thinning

Thinnings are one of the most "talked about," yet least understood, of stand improvement measures. The purposes are to increase the rate of growth of trees that remain after thinning and the total production of the stand. Several factors make thinnings of very low priority as a sale area betterment measure. Chief among these are: (1) Few immature stands suitable for thinning are included within timber sale boundaries. Hence, even if thinning were a desirable stand improvement practice, seldom could K-V funds be used for this purpose. (2) Thinnings made where the material cut cannot be utilized are very costly. Results to date in the white pine type indicate that returns from such thinnings will rarely balance costs of the job. (3) Response to thinning has been rather discouraging. In most tests in the white pine type unthinned stands have produced almost as much volume as thinned stands and in some cases even more. The same principles are likely to apply generally in the northern Rocky Mountains.

Thinnings are an intensive forestry measure, which to be successful should be applied lightly and frequently. They should wherever possible be a harvesting operation in which the material cut is utilized. If this is impossible, it seems better practice to delay thinning until such time as the material cut can be utilized and pay at least part of the thinning cost. Our hope in thinnings is to make them through ordinary sales procedure when markets develop for such products as pulpwood. It will be the policy, therefore, to do very little thinning with K-V funds.

Thinnings will not be discussed in the detail that they would if they were a high priority K-V stand improvement measure. The following material is included to give a better understanding of thinnings.

Three distinct types of thinnings are recognized, each based on a different principle in selecting trees to be removed. These are low thinnings, crown thinnings and selection thinning. The definitions on pages 7 and 8 distinguish between these three types.

Thinning From Below

Thinning from below anticipates natural mortality of the stand through competition by working upward from overtopped to dominant trees. The lighter grades of thinning from below are essentially salvage cuttings as they remove material which would otherwise be lost. At the present time, only when the stands are close to markets for such products as fuelwood and posts can low thinnings be made at a profit. Such thinnings, except perhaps the heavier grades, do not materially increase the rate of growth or improve the form of the remaining stand, but when made frequently and lightly they do increase the total production. If made in understocked stands or if too heavy they may actually decrease production.

Crown Thinning

Crown thinning is more difficult and requires a higher degree of technical skill than low thinnings. According to Hawley* these advantages include: (1) Bigger timber can be produced in the same time or timber of a required size in a shorter time. (2) They give immediate cash returns from the thinnings because the material removed is larger. (3) Any part of area not occupied by the main stand is utilized by the understory trees.

The principle of crown thinning is to cut in the upper crown classes in order to favor development of the most promising trees of these classes, meanwhile cutting in the lower crown classes only trees that will not live until the next thinning. Great flexibility, permitting the favoring and developing of fine individual trees, is characteristic of the crown thinning method. There are at least two ways of applying crown thinnings*. In one, the cutting in the upper crown classes may be so directed as to give more room to as many as possible of the most promising trees on the area without considering which of these promising trees will continue to the end of the rotation. In the other, a conscious effort is made to select the relatively few trees that will form the final crop.

In making crown thinnings close technical supervision and careful selection of trees are essential to improve the stand and to prevent high-grading. If release cannot be accomplished, then the cutting is unnecessary.

Crown thinnings offer the best possibility of any thinning method in the white pine type. The chance to cut salable material and yet leave a good growing stock is greater with crown thinnings than with any other thinning method.

*Hawley, Ralph C. Practice of silviculture, pp. 242, 243.

Selection Thinning

Selection thinning removes the largest dominant trees and the poorest overtopped trees. The former are cut to remove potential wolf trees and the latter to utilize small trees before they become a total loss. The obvious disadvantage of selection thinning is that it is too likely to result in a "high-grading" of the stand. When only dominants which are excessively limby or are taking up an undue share of the growing space are cut, the method can be beneficial providing their removal will not cause excessive damage to better residual trees. Growing stock is usually so reduced that the thinned stand does not produce as much volume as the unthinned stand. Selection thinnings may easily result in more harm than good. Only in exceptional cases should they be used.

We can sum up our recommendations on thinning in national forests as follows:

1. Ordinarily, do not thin unless the material cut can be used. Administrative use sales procedure should be used for this class of work. We will be able to do little thinning until better markets develop.

2. In thinning, care should be taken to maintain a healthy, vigorous, and full growing stock. Too heavy a low or crown thinning will so deplete the growing stock that yields are reduced. Heavy thinnings may also favor the development of ribes.

3. The thinning axiom, thin lightly and often, must be followed to obtain maximum production. To accomplish this, we believe that thinnings should be made every 5 to 15 years and that not more than 20 percent of the basal area should be removed in any one thinning (assuming that the stand is near normal at the start).

4. A rough spacing guide for field use is to thin such that the distance between trees in feet equals average d.b.h. in inches plus 3. Diagram shown in the appendix is a useful guide in regard to spacing of trees.

5. Selection thinnings are not generally recommended. Such thinnings will result in reduced yields. At times they may be desirable to remove trees of poor quality.

Pruning

The purpose of pruning is to increase the quality and value of potential crop trees. This is accomplished by removing limbs of the tree from the lower part of the bole to produce a higher proportion of knot-free wood. Pruning should be limited to the first 16-foot log in the tree. Usually, the first 16-foot log in five- to six-log trees contains from 25 to 35 percent of the total volume. Trees of the merchantable age of the future, 70 to 120 years, will contain very little of the high-value clear lumber without pruning.

Following is a summary of pruning practice to follow for quality production.

Tree Selection

Pruning should be limited to 100 to 200 of the best trees per acre. Trees selected should be straight for at least the first 16-foot log, well-formed, sound, vigorous, dominant or codominant. Coarse, very limby, rough, or scarred trees should be avoided.

Tree Size

Begin pruning when the tree is about 4 inches in diameter breast height. Prune in two or three operations, each pruning progressively removing branches at a higher distance from the ground, until the desired height is reached. The aim is to prune only "crop trees" which will be carried through to a large enough diameter to cash in on the pruning work.

Height to Prune

Prune sufficient height for one log only (about 17 feet). Cost of pruning above this height becomes excessive.

Amount of Crown to Prune

Do not remove more than 40 percent of the live crown length. A general rule that has been found satisfactory in stands with a closed crown canopy is to prune up to the point where contact between the branches of adjoining trees ceases.

Time to Prune

Pruning may be done at any time of the year except during the spring season of active growth. There is some belief that pruning during this period results in damage by turpentine beetle. Until study has proved that this is not true, pruning during this season should be avoided.

Tools

The pruning saw has been found the most satisfactory tool. It will be used for all pruning work. Although the ax is perhaps a faster pruning tool, it should not be used, as satisfactory work cannot be done with it. A ladder and hand saw to prune high limbs are extensively used in eastern plantations. Although this method produces high-quality work, its use in our region is generally impracticable because of the steep and brushy terrain encountered.

Methods

Branches must be cut smoothly and flush with the bole of the main stem or flush with the branch collar when present without injuring the bark. Pruning which removes the branch collar results in considerably faster wound healing* but it is believed that the extra cost involved does not justify the method. Special care must be taken, however, to cut the branch flush with the branch collar in order not to leave a stub. Do not leave splinters of wood. Cuts must be made without tearing or loosening the bark around branch stubs and without wounding the stem of the tree**.

Marking

Advance marking is very desirable. The usual tendency is to prune too many trees. Selection of trees in advance of pruning by an experienced man who continually checks his marking will diminish this fault. In some cases where highly trained crews are used, marking may prove unnecessary, leaving the selection of trees to the crew members with continual checks by the crew leader.

* Helmers, A. E. Pruning wound healing on western white and ponderosa pines. Northern Rocky Mountain Forest and Range Experiment Station Research Note 45. 6 pp., 1946.

**Hawley, R. C. The practice of silviculture. Fifth edition, p. 281.

Time Required

After getting to a tree the total pruning job ordinarily requires from 10 to 15 minutes per tree.

Spot Planting

The Planting Section of the Timber Management Handbook will be the guide for spot planting as with all other planting. It will be necessary, however, to depart from the instructions in this handbook until they are revised with regard to crew organization.

Species approved for planting will be in accordance with the Planting Section of the handbook.

Girdling

An ax notch penetrating 1½ to 2 inches into the wood, completely encircling the tree 2 to 4 feet above the ground, has been found a satisfactory girdling method for merchantable-sized trees in respect to cost and effectiveness.

Girdling is cheaper than poisoning. This latter method probably will largely replace girdling when poisoning methods have been developed. However, the advantage of girdling is that an ordinary ax is all that is needed. Girdled trees often provide material for development of beetle populations.

Poisoning

Poisoning has proven very successful in several regions for disposal of unmerchantable trees. Although still in the experimental state in this region, poisoning looks promising. We can tentatively recommend one poison, sodium arsenite, and believe that another chemical, ammonium sulphammate, will prove even more satisfactory when methods of application and dosages have been perfected. Poisoning requires plenty of safety measures.

Sodium Arsenite

A 15 percent solution by weight of sodium arsenite dissolved in water is used. (Mix 7 pounds of gray sodium arsenite in 4 gallons of water.) Apply this solution by means of a long-stemmed battery bulb obtainable at automobile supply stores. A convenient container for the solution is a 4-quart bottle with a mouth just wide enough so that the battery bulb, extending into the bottle, acts as a stopper. A long-spout oil can with a thumb-pressure feed is also very satisfactory.

Apply the solution in holes made by a poisoning ax* (diagram of ax is given in the appendix) at about stump height at the rate of one hole per 8 inches of circumference. The holes should be slanted downward in order to hold the solution.

Sodium arsenite is a powerful skin irritant and an extremely deadly poison. It must be handled with the greatest care. The person mixing the solution should wear rubber-treated gloves, a dust mask, and goggles. Workers applying the poison should wear rubber-treated gloves and handle the solution with extreme care.

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*This ax may be purchased from the Council Tool Company of Mananish, North Carolina. Cost in 1946 was $2.50 plus 70 cents postage.

On account of danger to livestock and wildlife, care must be exercised not to spill the poison on the bark of the tree or on the ground.

Ammonium Sulphammate (also called "Ammate" or "Dupont Weed Killer")

This is a much more desirable tree poison. In small amounts it is not poisonous to livestock, wildlife, or humans. As soon as satisfactory methods of application have been developed for Region One, this chemical should be substituted for sodium arsenite.

How to use this chemical is described by Fred A. Peevy of the Southern Forest Experiment Station as follows:

"The chemical is applied to large trees in 'cups' or notches at the base of the trunk as close to the ground as possible. A cup is made by cutting out a chip with two licks of a sharp ax. Make one cut about 2 inches above the other, each slanting down about 1 inch deep, and pry out the chip. A deep cut is not necessary. Apply the chemical immediately.

"The number of cups depends on the size of the tree. They should be spaced not more than 6 inches apart around the base of the trunk for large trees. Two cups are sufficient for trees up to 6 inches in diameter at breast height but larger trees require more. An additional cup is needed for approximately every 2 inches' increase in diameter. For example, a tree 10 to 12 inches in diameter requires at least five cups. One level tablespoonful of Ammate crystals is placed in each cup for trees over 3 inches in diameter. One heaping teaspoonful per cup is sufficient for trees less than 3 inches in diameter. The crystals are absorbed by the tree within 24 to 48 hours." It is probable that lighter dosages may prove adequate in Region One because the Southern Station tests were conducted with hardwoods that sprout vigorously from the stumps or root crowns.

The "Ammate" method for the removal of unwanted trees has several advantages over felling in removing trees 8 inches d.b.h. and over. Poisoned trees will stand for several years before they fall and during this period they help protect neighboring slender stems from snow bend. Poisoning is also less apt to seriously damage neighboring trees, since the needles and small branches have already been shed when the tree comes down. In addition, poisoning does not create the slash or insect hazard that may result from felling.

Insect Damage

Stand improvement measures resulting in an accumulation of debris require consideration of the possibility of bark beetle populations developing which can subsequently become destructive. This is often a problem in the ponderosa pine type.

Trees felled in improvement and release cuttings may create conditions favorable to an outbreak of bark beetles unless precautions are taken. The need for direct preventive action will vary with the season of year cutting takes place, the concentration and size of freshly felled material, and the prevailing beetle situation on the specific area. Under the following conditions, there will ordinarily be no need for special measures to reduce beetle hazards:

1. Where trees are poisoned rather than felled.

2. Where felling is carried on during the period September through March.

3. Where felling is accomplished within 2 months following regular timber cutting.

4. Where there is no concentration of material over 4 inches in diameter.

All trees over 8 inches d.b.h., and all green material in concentrations, should be strip peeled down to a minimum diameter of 4 inches. Unpeeled strips of bark should not exceed 4 inches in width.

Testing New Methods

All field officers are encouraged to be alert to possibilities for improving established practices and methods, and for developing new methods. But this encouragement should not be taken as permission to disregard established methods promiscuously and without adequate advance planning. Before undertaking trials of new methods that involve more than very modest outlays of money or labor, it should be ascertained that the subject of testing has (1) promise of real merit in reducing cost, bettering results or accomplishing other legitimate purposes, and (2) has not already been adequately investigated elsewhere and found wanting. Wasting efforts on poorly conceived tests or duplicating tests that have already been adequately investigated elsewhere is as much reason for censure as any other unacceptable performance.

V. ORGANIZATION OF WORK

Careful and efficient organization of crews and crew work is necessary to avoid confusion and waste of funds.

It is usually desirable to break up the area to be treated into small units. Sometimes natural boundaries such as creeks, ridges, gulches, etc., can be used. String lines can be used to divide the area into strips, particularly in dense stands. Each man can be assigned a strip and be responsible for a definite unit which the foreman can check. The area is covered completely and systematically.

The size of crew will vary depending on the kind of work and the experience of the men. The crew may range in number from 4 to 10 men to each foreman or qualified strawboss. It is difficult adequately to supervise larger crews.

Where several distinct operations are to be carried out in the same area, it is best for a separate crew to perform each operation. For example, cleaning, improvement cutting, pruning, and slash disposal are to be performed in an area. Damage to young growth may result from the felling of large trees in the improvement cutting, hence a special felling crew should precede the cleaning crew. The cleaning crew will then cut in the young growth. Next will come pruning, and finally a crew will take care of the slash.

When trees are to be pruned to a height greater than 7 feet, pruning of successively higher sections should be organized as a separate job rather than one man carrying the necessary saws to do the complete job. Either of two methods can be used. The crew can be properly divided with some members using hand saws working in advance, followed by members equipped with pole saws mounted on 8-foot handles, and these in turn followed by workers with pole saws equipped with 12-foot handles. The other method is to equip all crew members with the same tool and complete each height of pruning in the stand before proceeding to the next height. It must be remembered that use of pole saws is much more tiring and difficult than a hand saw. When using pole saws, eyes should be protected from sawdust by goggles.

Pruning lends itself ideally to contract work. Regions Five and Six have been very successful with contract pruning jobs. Included in the appendix is a sample contract used by Region Six for such work.

Stand improvement demands very close supervision. Crews should be taught to cut corners, to avoid doing too much, not to "polish," in short, to buy the most for each dollar expended.

Spot and fill-in planting will require about the highest level of planting skill available as the work will be pretty much an individual job. Each planter will be responsible for planting his block so that the planted trees will contribute to effective stocking of the area. He must be trained to pick spots where planted trees will be effective. He should be cautioned to avoid unstocked spots which are too rocky or brushy for development of planted trees. Spots dominated by residual trees should not be planted.

Marking

Necessity for marking depends on the kind of work and the training and experience of the workers. In cleanings, for example, it is impractical to mark each tree to be cut or reserved. A better procedure is to train the cutting crew to select the trees. Although the training required for unskilled labor is considerable, the time is well spent. At the beginning of a job, it is desirable to demonstrate the work on several small sample areas of a tenth to a half acre each and to explain the process thoroughly to the crew. During the progress of the work, the practices should be checked currently for consistency and adequacy.

In stands where crop trees are not selected, the cutting crews may be trained to become sufficiently skilled in the principles of stand improvement to permit work without marking. A good arrangement in these stands is to work the first crew of cutters through the stand with instructions to leave doubtful trees. The foreman follows this crew with a small crew who complete the operation under his direct supervision.

In such work as pruning, thinning, improvement cuttings (in fact, in all work done on a crop-tree basis) marking is frequently desirable. Marking concentrates the necessary training and decision for the selection of trees in one man per crew rather than the whole crew. The result is usually an increase in quality of work and in output. However, marking must be performed by fully qualified personnel. It should be done in advance of the cutting crew. Mark either trees to be cut or trees to be left, whichever are fewer in number.

Marking ordinarily is best accomplished by means of a paint gun, although there are several other satisfactory devices such as lime bags, swatters, and tags. Division of the area into strips or blocks by means of string lines is an aid to marking. It is essential to mark the trees in a stand on the same side to the greatest possible extent because this simplifies finding the trees, checking, and inspecting the job. A good practice is for the marker to pick out first the trees he considers the best crop trees and then one by one determine which, if any, trees should be cut to give proper release.

Where stands are dense, there is a tendency to mark far too many leave trees per unit area. In the more open stands, the reverse may be true.

Tools

Some of the tools commonly needed and their uses are listed below:

1. Stems less than 2 inches in diameter can best be cut by means of hand shears of the type of the No. 3 "Forester's" tool*. A skilled axman also can cut trees of this size efficiently with a 2½-pound ax. When shears are used, the shear crew can go through first and cut the trees less than 2 inches in diameter. The shear crew should then be followed by the ax crew cutting the larger trees.

2. Trees between 2 inches and 10 inches should be cut with 2½- to 3½-pound ax.

3. Trees larger than 10 inches should be cut by felling saws.

4. Pruning should be done by means of saws. A curved California saw with 5 to 8 points per inch, long needle teeth, and pull stroke is one of the best for low work. For greater heights various tools and methods have been used, but pole saws are recommended. A heavy 17-gage, 5-point, 18-inch curved pull-cut saw, mounted on poles of various lengths, depending on the height to be pruned, is satisfactory.

   Up to 7 feet - use a hand saw.
   From 8 to 12 feet - use a saw mounted on an 8-foot pole.
   From 13 to 17 feet - use a saw mounted on a 12-foot pole.

   Goggles should be worn by workers using pole saw.

5. Girdling ordinarily will be done by means of a 3½-pound, double-bitted ax.

6. Methods of poisoning are in the experimental stage and recommendations may soon change. At present, poisoning will require a poisoning ax, 4-quart bottle fitted with a battery bulb, and larger containers for preparing sodium arsenite solution.

7. A regular planting mattock will be used for planting.

Slash Disposal

Economy in slash disposal will be a major consideration in planning S.A.B and T.S.I. projects.

Intensity of slash disposal will vary according to the type of work, the amount and kind of slash, and the position of slash.

In general, the same standards and policies will be followed as in the disposal of logging slash. These are covered by M-1099-R1, and will be included as supplements in the Timber Management section of the Forest Service Manual.

No slash disposal is necessary with cleanings. Slash is light and does not constitute a serious fire hazard. Occasionally it may be desirable to dispose of cleaning slash where accumulations occur along trails and roads that are used as firebreaks. However, burning of cleaning slash will encourage the germination of ribes seeds in the white pine type and further is apt to scorch small trees. These points should always be kept in mind when planning for disposal of any cleaning slash.

Except for disposal of slash along roads and in other special cases, the slash from thinnings need not be burned. Lopping tops and scattering the slash close to the ground reduces the fire hazard to some extent, hastens decomposition,

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*Manufactured by the H. K. Porter Company, Everett, Massachusetts.

improves appearance, but adds materially to the cost of the job. Lopping and scattering should be practiced only when it is particularly important that the fire hazard should be kept down or when improved appearance warrants the additional expense. Pruning slash will be left as it falls. Burning is not necessary.

VI. PLANS AND RECORDS

For stand improvement projects not financed by K-V deposits or handled as administrative use, form M-1014-R1 (copy in appendix) should be used. Form M-1014-R1 can be used as a planning report by crossing out words and items not applicable. For sale area betterment work a preliminary plan will be presented under item B-2 of form M-1063-R1, "Outline for Timber Sale Report." Plans for sale area betterment work should be based on a field survey. A brief, concise statement covering S.A.B. field survey will be included as an introductory statement under item B-2. For sales having marked differences of age class and silvicultural conditions, S.A.B. work should be planned by units. Sale area betterment plans and estimate of costs will be summarized under item B-2 in the following form, listing only the items of specific application to sale being appraised:

S.A.B. Plan and Appraisal Summary

	Acres	Cost per acre	Total ($)
(1) Site preparation			
(2) Planting or seeding			
(3) Cleaning			
(4) Liberation			
(5) Thinning			
(6) Improvement			
(7) Pruning			
(8) Other			
Total cost of work			
(9) 11 percent for overhead			
Total cost			
Cost per unit of volume cut			
Recommended K-V deposit per unit of volume			
Estimated deposits per acre for net area of sale			
Estimated expenditures per acre treated			

Following comments refer to numbers in parentheses:

(1) Make separate entries for scarification, slashing, and prescribed burning.
(2) Include cost of trees or seed.
(3) to (6) Report estimated number of trees to be cut per acre.
(7) Report pruning heights and number of crop trees per acre.
(8) Report in detail other work.
(9) Overhead covers planning, inspection, recruitment, and accounting work only. Tentative distribution - 3 percent for regional office, 4 percent for supervisor's office, and 4 percent for ranger district.

Allotment Procedure

Prior to expenditure of K-V funds, final plan will be prepared and submitted to supervisor for approval. Allotment of funds will ordinarily be made in an amount to cover work approved for current calendar year.

Progress Records

1. Map (preferably on scale of 8 inches equals 1 mile) will be used to show portions of sale area treated. Use of legend showing planned treatment and date work was completed by steps by units is suggested.

2. Cumulative annual summary of K-V earnings, allotments, expenditures and accomplishments by individual sales. Form M-1070-R1 shown in appendix will be used. In column 2 "Dollars of K-V earned," on-the-sale work is equivalent to 89 percent of value reported to date from form 820, "Report of Timber Cut." Entries for past calendar year should be made and forwarded to supervisor's office for initialing prior to February 1. For regional forester and Chief's sales, supervisor will forward prior to February 15 report showing only cumulative totals and high lights of S.A.B. plans and estimated expenditures for the coming field season.

Permanent File

Since S.A.B. expenditures are likely to be made from 5 to 10 years after sale is closed, it is essential that records be kept in the "live" files. When sale is closed a folder will be labeled "Sale Area Betterment Record" with the sale designation. In this folder will be placed progress map, memorandum covering future plans, cumulative sale area betterment summary, and such other pertinent information from sale folder as will permit subsequent resource managers to carry out sale area betterment work in an orderly manner.

Planting Reports

Planting reports will be submitted in accordance with requirements in the Planting Section of the Timber Management Handbook. A cross reference to planting reports will be placed in sale area betterment file.

VII. S.A.B. AND STAND IMPROVEMENT MEASURES BY FOREST TYPES

Western White Pine Type*

Stand improvement and sale area betterment for the western white pine type are divided into measures applicable to mature stands and measures applicable to immature stands. In mature stands the essential purposes are to dispose of unmerchantable timber and to establish desirable reproduction. In immature stands, the objective is mainly to increase the proportion and the quality of the more valuable species.

In both immature and mature stands of the white pine type, trees removed through the application of cultural measures ordinarily show appraised value below minimum stumpage rates. However, lumber prices, accessibility and utilization standards are changing, and opportunities should be watched for, either to sell the materials cut or to remove the timber under administrative use without resorting to collection of K-V deposits. In certain cases, K-V funds may be effectively used to make cleanings, but the bulk of the funds will ordinarily be used on disposal of defective trees and in planting. The following table summarizes priorities:

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*Much of the material pertaining to white pine, both in this section and elsewhere in this handbook, has been taken from "Stand Improvement Measures for the Western White Pine Type," by Kenneth P. Davis, 63 pp., processed, Northern Rocky Mountain Forest and Range Experiment Station, 1936.

Priority of Treatment for the Western White Pine Type Inside Blister Rust Control Units

Treatment	To be done with K-V funds	Priority of work
Elimination of defective residual stands (felling, girdling, broadcast burning)	Frequently	1*
Planting	"	2*
Cleaning	"	3
Liberation cutting	Occasionally	4
Pruning	Seldom	5
Improvement cutting	Rarely	6
Thinning	"	7

*Refer to unit management plan as to urgency of prompt establishment of a new crop of white pine.

The Type

The western white pine type is characteristically a mixed forest of variable association of six or more species. Stands are normally even-aged, or at the most, composed of two or three age classes. Truly all-aged stands are seldom found. In general, stands containing less than 50 percent of western white pine by volume are most common and pure stands are infrequent. There are, however, many stands throughout the type that contain more than 50 percent western white pine.

The principal associates of western white pine are western larch, Douglas-fir, grand fir, western hemlock, and western redcedar. In addition to these five species, Engelmann spruce, alpine fir, ponderosa pine, and lodgepole pine are minor associates of importance. Based on existing and anticipated future values, the relative desirability of the principal associated species within blister rust control units is as follows, ranging from most desirable to least desirable:

Western white pine	Douglas-fir
Western redcedar	Lodgepole pine
Western larch	Grand fir
Ponderosa pine	Western hemlock
Engelmann spruce	Alpine fir

Ponderosa pine would ordinarily rank next to western redcedar, but is placed lower in the list because of evidence of its poor showing on good white pine sites. It should be given a higher rating on the fringe of the type where it does better. At best this rating of species is only approximate as the site and local markets may give a certain species such as grand fir a higher rating than shown in this listing. Outside of blister rust control units, white pine, though still commercially desirable, will be at the bottom of the list because of its susceptibility to blister rust.

Relationship to Blister Rust

Where white pine is to be grown as a crop, blister rust control requirements are the dominant factor in determining management practices. All sales preparation, sales administration, and cultural work must be completely coordinated with blister rust control as to practices, methods and timing. Stand treatment can materially aid or impede blister rust control, depending on what is done and how and when it is carried out. All operations in white pine management, including blister rust control, must be carefully correlated if white pine is to be grown at a profit. Be sure to study "Make It a White Pine Project," starting on page 104 of 1948 publication entitled "Development of a Blister Rust Control Policy for the National Forests in the Inland Empire," by Don N. Matthews and S. Blair Hutchison.

The 1948 Matthews-Hutchison report in full should be required reading for all white pine managers. It contains valuable basic information regarding the economic aspects of white pine management and the development of the unit management concept.

A study of the report brings out clearly the fact that the old "control zone" as such is no more. Rather, the program now is made up of white pine management subdivisions, the component parts of which are the individual control units as defined by the study. These may be individual units or contiguous groups of units which have been selected on the basis of over-all economic management considerations, feasibility of control, cost of control per M of pine produced, and timing of the harvesting, all with relation to the funds available for protection and management.

Units within the scope of the funds presently available may be termed primary units, and are those in which work is currently progressing or is definitely planned for within the first 20-year period beginning at the date of plan. Units not included in the current plan are called secondary units. These are listed in the order of priority for inclusion in the current control program when:

1. Appropriations become sufficient to cover more units.

2. Costs are reduced through better methods of control to allow a greater coverage by current appropriations.

3. Changes in management plans require a realignment of units.

Likewise, primary units may be dropped from the current plans for management reasons, changes in pathological conditions, or decreased appropriations, although every effort will be made to avoid dropping a unit once placed in the primary category.

Upon completion of the unit analyses and the development of forest and regional programs therefrom, each forest will have a designated list of primary units for which detailed management and silvicultural plans will be made and recorded. Stand improvement measures will be a part of these plans, to be provided for in each case according to the needs of the particular unit and in accordance with the general instructions contained in this handbook.

In primary units all funds which are available including BRC and planting appropriations, as well as K-V and slash disposal, will be considered as white pine management moneys, and will be expended as such in accordance with the aforesaid plan.

Secondary units are not to be considered non-white pine units, except for those which are clearly outside of any foreseeable protection program. They will be listed by priorities as mentioned before. From this list there will be eliminated the obviously impractical units. The remainder will be so managed that the blister rust control problem will be held to a minimum by partial cutting, prescribed burning, and the chemical treatment of ribes which germinate on roads, landings, and in natural openings. The objective is to provide for ultimate control with a minimum of expense and no current expense from appropriated blister rust funds. In secondary units approved by the regional forester, K-V and slash disposal funds may be used to accomplish the desired objective.

Treatment of Mature Stands

Treatment of mature stands is primarily concerned with the disposal of trees, hopelessly unmerchantable because of poor form or defect, and unmerchantable understory trees, mainly suppressed hemlock and grand fir left after logging. Disposal of this unmerchantable material has the highest priority providing approved unit management plans show need for establishment of new stands of white pine.

A large proportion of mature and overmature stands of the white pine type contain much unmerchantable timber. If the sites are to be restored to a productive condition after logging, the unmerchantable material must be eliminated by some means. The disposal job is usually expensive, no matter what method is used. Such disposal and its relation to blister rust control is one of the most difficult management problems of the type.

We are not concerned with sound timber left after logging which is unmerchantable because of current lack of a market. The policy will be to reserve such timber until markets develop. However, there always will be border-line stands containing some sound mixed material which it may be in the public interest to destroy in order to rehabilitate the site. In general, a residual stand containing 4,000 or more board feet per acre in sound trees should not be destroyed. Foregoing guide is dependent on species, accessibility, and economic desirability of prompt establishment of white pine as determined by unit analysis.

Need for this class of work should be largely transitory. Once the mature and overmature stands are cut, and the sites they occupy are rehabilitated, they will be managed and cut at younger ages. Hence, there will be less defective material. The problems caused by it will largely disappear. For the present, however, foresters in the white pine type are faced with a difficult rehabilitation problem. It can be solved only by meeting it squarely. K-V deposits offer the only possibility of performing the necessary work at present. Elimination of unmerchantable trees can be accomplished by four different methods or combinations of these four, depending on the requirements of the area involved. These methods are: (1) Felling, followed usually by piling and burning the resulting slash. (2) Girdling. (3) Poisoning. (4) Prescribed burning, which may or may not be preceded by felling the residual stand. Each of these methods will be discussed in detail.

Felling, Followed by Piling and Burning of Slash

By far the greatest amount of stand improvement accomplished in the western white pine type has been by felling the unmerchantable trees left after logging followed by piling and burning the resulting slash. For lack of a more descriptive term or specific name, this work has been variously termed forest

sanitation, sale area betterment, "hemlocking," and sometimes simply stand improvement. Silviculturally it may be a liberation cutting, a sanitation cutting, or part of a shelterwood cutting. In recent years the method has run contrary to the best blister rust control practices. It tends to favor the establishment of ribes and sets up a difficult or impossible situation for ribes eradication and the safe establishment of white pine. As a result, the method has had to be largely abandoned within blister rust control units. In addition, the practice is more costly than any other disposal method. Before the war the cost of this work in defective hemlock and grand fir stands averaged about $40 per acre. At present it would cost much more; accordingly "hemlocking" is of very limited use.

Girdling or Poisoning

Where aesthetic and fire control objectives will permit, girdling or poisoning are satisfactory methods of eliminating unmerchantable trees.

Between 1916 and 1930 girdling was widely used in the white pine type for the disposal of unmerchantable trees. It was abandoned, however, because of the resulting fire hazard. Nevertheless, when applied in moderation, it should have a place in the silvicultural practice of the type. It is a much cheaper method than felling. If the number of girdled or poisoned trees per acre is kept to a maximum of 15 to 20, the methods should not prove objectionable on areas where conditions are such that fuel rating will not exceed medium-medium.

Prescribed Burning*

The only practicable method of disposing of large quantities of unmerchantable timber remaining after logging in many mature and most overmature white pine stands is by prescribed broadcast burning.

There are a number of advantages to broadcast burning. The fire hazard is reduced below that which results from any other method. It is the only practicable means of disposing of large quantities of inflammable material. It produces excellent pathological sanitation and when properly applied is especially effective in blister rust control through destruction of ribes. The soil is put in good condition for planting. The method produces quick results. It is cheaper than any alternative.

The major criticisms or disadvantages of prescribed broadcast burning are two in number. The first is damaging effects on the soil. Without entering into discussion of the subject, this much may be said in its defense. Western white pine forests are naturally fire forests; western white pine owes its present abundance to fire which in the past has periodically reversed the successional trend toward a climax forest principally of western redcedar, western hemlock, and grand fir. Prescribed burning closely simulates a natural process that has gone on in Nature for thousands of years, a process that has produced some of the most valuable stands found today.

The second objection to prescribed burning concerns aesthetics. Prescribed burns are not pretty. But lands do not stay black after burning. This objection can be overcome only by education in the purpose and results of the method.

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*Much of the material in this section has been taken from "Controlled Burning in the Western White Pine Type" by Kenneth P. Davis and Karl A. Klehm. Journ. For., pp. 37, 399, 407.

The place of prescribed burning in white pine silviculture has become even more important in recent years with appreciation of its value as a blister rust control measure. When properly used, it can be of greater aid than any other silvicultural measure in blister rust control. Under present conditions, prescribed burning is one of the major methods to be used in rust control.

Information on how to employ prescribed burning effectively is a major need. Certain principles, methods, and guides are known which have proved successful in prescribed burning for slash disposal and hazard reduction, but prescribed burning for ribes suppression adds a new demand and is much more exacting if the desired results are to be accomplished. The answers are not all in. Though guides can be stated, much needs to be known.

It is believed that two methods of prescribed broadcast burning will have a place in practice, especially within blister rust control units. These are the single burning and the double burning.

Single Burn

This is the method which has been widely used in the past in the white pine type. With this method all live and dead timber is felled. The material on the ground is then broadcast burned in one operation.

Single burning should be most applicable to the following situation:

1. Areas where little standing defective timber is left after logging, or where a single burn will leave insufficient fuels for a second burn.

2. Areas of steep and broken topography, where at best broadcast burning is hazardous. With all fuels on the ground, control of the fire is more certain.

3. Areas bearing much hemlock and with little logging slash of white pine, grand fir, or cedar to carry the first "creeping fire" needed in the double burn method. It may prove difficult on such areas to obtain an effective "creeping fire" even though all defective timber is felled to build up the fuels and even though the area is burned in a very dry season. Hemlock slash is not as good fuel as white pine, grand fir, and cedar.

Area Selection. Good selection and lay-out of the particular area to be treated contribute greatly toward success of the project. The following items are important:

1. Within blister rust control units, the area must be of a size, shape, and character such that it is not greatly influenced by ribes or rust conditions outside the area and does not affect these conditions greatly. In brief, it must be a "unit" with respect to blister rust control.

2. The area should be in segments each of which can be completely burned over in a single day (or night). It is unsafe to leave unburned portions that may burn out disastrously the following day. If the problems of burning technique are at all complex, 200 acres is about a maximum area that can be burned safely at one time.

3. The boundaries should be as regular as possible. Sharp turns, long fingers, and deep indentations always make for trouble in fire control and at the same time often cause an irregular burn, unsatisfactory reduction of fuels, and complete failure as a ribes destruction measure.

4. In laying out the area, full advantage should be taken of available firebreaks, such as roads, streams, ridge tops, clearings, and natural openings.

5. Do not attempt to burn stream bottoms or swampy areas. Chemical control is practicable for such areas.

Preparation for Burning.

1. The purpose of felling is to concentrate the fuels so that they will be consumed and ribes bushes and seeds destroyed. Trees and snags should ordinarily be felled up and down the slope.

2. It is usually worth while to lop limbs from the top side of felled trees lying within about 50 feet from the outer edge of the area, and to bunch slash along the edges. This makes fire much easier to start and promotes consumption of fuels along the edges where the greatest difficulty in getting a sufficiently hot fire is usually experienced. Lopping and occasionally some bunching of slash should also be done where a hot fire is not aniticpated in areas of light fuels. Lopping and bunching is not necessary in areas of heavy slash and in no case should it be done until the felling is completed and the need is evident. Much time can be wasted by unnecessary lopping and bunching. More lopping and bunching is needed with hemlock fuels than of other species, as hemlock is a relatively poor fuel.

3. Snags standing outside the area within a distance of 75 to 100 feet should be felled. Where fire control difficulties are anticipated, as at the head of gulches or in low saddles, snag felling should be extended for 200 feet or sometimes an even greater distance beyond the area to be burned. Standing snags outside the area are one of the principal hazards in burning.

4. A firebreak 10 to 20 feet wide, cleaned of all logs and branches, but not the natural duff, should be constructed around the area except where natural firebreaks are available. Width should vary according to heat that will be generated, slope conditions, and type of fuels outside. Spotting usually causes the most trouble - not fire spreading across firebreak. However, control in burning is based more on good preparation, favorable fuel and weather conditions, and skillful direction of the actual burning than on firebreaks. Firebreaks are best constructed by bulldozers.

5. A trench dug to mineral soil within the firebreak is seldom needed completely around the area. Trench should be constructed before burning only in areas of dry grass, heavy duff and rotten wood, where the need is definitely apparent.

When to Burn. Timing is the phase of burning practice where information is weakest. Two apparent timings are involved. Within blister rust control units the first timing covers the period from felling the residual stand until burning. Sufficient time must elapse for ribes seed stored in the duff to germinate, or to be devitalized; yet sufficient time must not elapse for the ribes which do germinate to produce seed in abundance. Usually, the period needed for ribes suppression varies from 3 to 5 years.

The other timing has to do with when to burn within the season selected for burning according to the above ribes suppression needs. Determination of the best time to burn necessitates careful evaluation of weather, fuel, and safety factors. Hard and fast rules are not possible, as much depends on judgment. Methods developed in Region One to measure fire weather and forest inflammability should be used as a guide. Weather and fuel conditions must be such that

fire will spread and burn hard in order to destroy fuels and kill ribes plants. Unfortunately, guides which used to be considered satisfactory for obtaining satisfactory burns for fuel reduction are not necessarily satisfactory for ribes suppression.

The Fire Must Burn Hard Over the Complete Area. Burning should not be attempted immediately (i.e., a few hours) preceding an impending storm, as weather changes may be sudden and unpredictable. An unexpected wind, for instance, may cause serious trouble. The U. S. Weather Bureau should be consulted in advance for a complete forecast of weather conditions, especially of dangerous winds during the burning period.

Forecasts from the Weather Bureau upon special request covering local conditions are of material aid in burning at the best time.

The fuel volume also has a large bearing on success or failure of burning. Heavy fuel concentrations will generate sufficient heat to burn satisfactorily when fairly green or damp from recent rains. Actually, the heavier the slash the more safely it can be burned, as burning can be done when the fire danger is relatively low. Light or scattered slash, on the contrary, must be burned when relatively dry and the fire danger consequently high or the fire will not spread, consume fuels satisfactorily, or destroy ribes.

Fall is ordinarily the best season for burning. During a season of relatively low fire danger, the last half of August is the time to burn. In the spring, although the outside of branchwood and logs may be dry, the inner portions are apt to be too wet for complete destruction. The ground surface, too, is usually too wet to permit a hot fire which will destroy ribes. It is therefore difficult to accomplish the elimination of more than the finer fuels. Once a fire has covered an area and consumed the finer fuels, it is almost impossible to get a satisfactory fuel reduction by a second fire except during midsummer. Another objection to spring burning is that fires may hang over and break out at inopportune times during the summer fire season.

Within limits of safety, the drier fuels are burned, the better. The burn must be hot and hard to accomplish the objectives of burning.

Double Burn

Double burning was developed on the Kaniksu National Forest to get a cheaper prescribed broadcast burning method than single burning and one which would be more efficient in destroying ribes seeds and plants. As the method has received only a very limited trial, little is known of the when, where, and how of this method or of the results to be obtained. About all that can be said is that the method should have several advantages where it can be applied; for this reason it should be thoroughly tested.

The method consists of two broadcast burns. The first is a broadcast burn of logging slash by a "creeper fire" to: (1) Destroy logging slash, (2) kill as much of the standing green defective timber as possible by burning around the roots and root collars, (3) destroy ribes seed by burning and altering storage conditions to cause devitalization, and (4) to create conditions for germination of those ribes seed which are not destroyed. The second burn is made in from 3 to 5 years after the first burn. By this time the residual stand killed by the first fire is supposed to have disintegrated enough to build up sufficient fuels on the ground to carry a second burn. Some felling by power saw or bulldozer may be needed to further build up the fuels. Ribes seeds not destroyed will have germinated. The second broadcast burn is made to:

(1) Destroy the fire hazard, (2) destroy the ribes bushes and any ribes seed not yet destroyed, and (3) put the area in shape for planting.

The major disadvantage of the method is that it may be more hazardous than single burning. To accomplish the objectives, burning will have to be done when fuels are very dry. Burning where there is much standing material is more difficult and hazardous.

The major advantage, if the method proves successful, is the greatly reduced cost of the disposal job and the possibility of better ribes suppression.

Double burning should be most applicable to the following situation:

1. On flats where fire is not as difficult to control.

2. Where fuels are sufficient for two burns. Sufficient defective material must be left after logging to provide fuel for the second burn.

3. Where logging slash is heavy and composed of such species as white pine, grand fir, and redcedar, western hemlock slash is a poor slash for carrying a "creeper fire." If insufficient logging slash occurs to carry the first burn, it may be augmented by felling some of the defective material.

Burning Technique

References on burning technique are: (1) Fuel Hazard Reduction section of Region One Fire Control Handbook, (2) "Principles of Fuel Reduction" by C. K. Lyman, (3) pages 44 to 50 of 1936 publication by Kenneth P. Davis entitled "Stand Improvement Measures for the Western White Pine Type."

Regeneration Following Burning

Prompt and complete regeneration following prescribed burning is essential to realize on the heavy investment necessary. These requirements can be met best by planting. Planting of prescribed burns following the usual "waiting period" ranks high as a K-V measure.

Planting can and must be done before the areas brush over. Generally, planting can be undertaken the third or fourth year following burning, but not unless preceded by the initial ribes eradication working of the burn.

As planting practice is covered completely in the Planting Section of the Timber Management Handbook, it will not be discussed here.

Treatment of Immature Stands

Spot Planting

Spot planting ranks high in priority as a stand improvement measure in the white pine type. Within blister rust control units, it is of importance to insure full stocking of white pine to pay out on costs of blister rust control. Outside of blister rust control units, it is also of importance to insure fully stocked stands of species other than white pine.

Where stands have been partially cut, reproduction should be well established at the time of the final cut. At this time stocking surveys should be made to determine adequacy of natural regeneration. Where natural regeneration averages less than 500 well-distributed trees per acre (500 white pine within

blister rust control units), spot planting to increase the young stand to at least 500 well-distributed trees per acre should be done if planted trees will have a reasonable chance to become established. However, spot planting will not be done unless at least 50 trees can effectively be planted per acre.

White pine will not be planted until the ribes problem has been eliminated on the area as determined by the relative accomplishments of slash burning and ribes eradication measures. Newly disturbed areas require careful watching over 12 to 15 years for ribes regeneration before placing them on a maintenance basis.

Cleaning or Weeding

Within blister rust control units, cleanings offer great promise of maximum returns. Experience has shown that cleaning can be most effectively and cheaply accomplished when the stand is very young. As the stand grows older, expense of treatment rapidly increases, and at the same time, less can be done to improve composition which becomes more fixed with increasing age. To obtain improvement in composition of older stands, a heavy sacrifice of growing stock is necessary, a sacrifice that can be largely avoided by early selection to concentrate growth on the most valuable stems.

Blister rust control has increased the importance of cleanings within control units. Here as much white pine as possible must be grown per acre and per unit in order to justify blister rust control costs. Cleanings are the cheapest means of controlling species composition in natural stands. With the use of partial cuttings, which favor the tolerant species such as grand fir and western hemlock, cleanings become even more necessary if the next stand is to contain a good proportion of western white pine.

To make cleaning worth while minimum stocking is about 300 vigorous, well-spaced white pine per acre. Rough guides in thinning are: (1) A stand of from 1,000 to 2,000 stems per acre after cleaning. (2) A stand after cleaning which will yield at least 70 percent white pine, but also trees of lesser heights, especially of the intolerant species, should be cut. A follow-up cleaning after 3 to 5 years is desirable to eliminate the fast-growing competitors that have become prominent since the first operation. Information available on the development of white pine in relation to its principal competitors is summarized in table 1 of the appendix. This table also gives general rules for treatment. White pine is intermediate in tolerance, leaning toward the intolerant side. It can become established under light to moderate shade conditions, but does not develop or grow well under shade. It is intermediate in persistence under shade conditions. In competition with less tolerant species, principally larch, lodgepole pine, and ponderosa pine, white pine is, in the open, strongly overtopped during the early years of stand development. However, unless badly overcrowded, the more tolerant white pine will overcome its early growth handicap and will form an important component of the stand at maturity. Under shade, larch, lodgepole pine, and ponderosa pine cannot compete with white pine. In competition with more tolerant species hemlock, western redcedar, grand fir, and Engelmann spruce, the opposite is true. Under shade, white pine will lose ground to these species, while in the open it will from the first largely dominate them. All things considered, the development of white pine is best in the open. Stands with an overhead shade greater than 30 percent should not be cleaned until the overwood has been removed.

Blister rust control is not influenced appreciably by cleanings, except where slash is burned. However, cleanings must be geared closely to blister rust control plans in order that only stands protected from blister rust be cleaned

and these only when they are relatively free of ribes and blister rust infections.

Cleanings will seldom be used as a stand improvement measure in the white pine type outside of blister rust control units. Occasionally it may be desirable to favor a certain species by cleaning. Where this occurs the same guiding principles as outlined for white pine will be followed.

Liberation Cutting

Liberation cuttings are made in young stands, not past the sapling stage, for the purpose of freeing the young trees from older individuals that are overtopping them. "Liberation cuttings are made during the same period in the life of the stand as cleanings, but differ in that they take out trees larger and older than the young stand, whereas cleanings remove trees of approximately the same age as those freed."*

Many cut-over areas in the white pine type, carrying a residual stand of defective or low-value trees, have been opened up sufficiently for reproduction of all species to become established. On these cut-over areas white pine is at a special disadvantage because it cannot compete successfully with its more tolerant associates under the shade of the residual trees. Liberation cuttings are needed to release the reproduction, followed in many cases by cleanings to improve the composition of the young stands.

The use of partial cuttings in the white pine type as a blister rust control measure will result in more and more stands in need of liberation cuttings. As these residual stands will contain a much higher proportion of the valuable species than stands cut over in the past, chances of making subsequent sales and collections of K-V funds will be much greater.

Whenever possible, regular sales procedure will be used to make liberation cuttings. If the residual trees are sound, but not marketable, they will be reserved until such time as they become marketable, even though this means losing the white pine in the understory because of shade. The hope is that these sound trees will eventually be merchantable as sawlogs or pulpwood.

Liberation cuttings, like all other measures in the white pine type, must be correlated with blister rust control. Within control units, such cuttings take on added importance to assure that the next crop will contain adequate white pine. The effect of these cuttings on the germination and development of ribes must be carefully considered for each area within control units. Where the cuttings and necessary slash disposal will result in a new crop of ribes, then prescribed broadcast burning of slash and unmerchantable material should be favored. Only where the cuttings will not result in a new ribes population, and where slash does not need to be destroyed, should girdling and poisoning be used to kill residual trees. Girdling and poisoning will have little influence on blister rust control except where the resultant increase in light intensity will permit additional ribes to become established.

More than ordinary care in logging must be observed when making liberation cuttings in order to protect the young stand from damage. Care in felling, skidding, and disposal of slash are especially important. Trees should be felled to injure young growth as little as possible. Horse or jammer skidding is preferable to tractor skidding. Slash should be pulled free from young growth. Disintegration of girdled or poisoned trees will cause negligible damage to the young growth.

*Hawley, R.C. The practice of silviculture. Fifth edition, p. 208.

Pruning

Pruning, though a permissible K-V operation and one of the more desirable of stand improvement practices in the white pine type, can seldom be financed from K-V funds. Suitable stands for pruning are rarely included within timber sale boundaries. Where such stands are included, and all K-V deposits are not needed for other stand improvement work of higher priority, pruning should be performed.

An aspect of artificial pruning of white pine which has been receiving increasing attention is to remove the lower live branches as a blister rust control measure. Infected branches which might spread infection to the main bole and thus result in death of the tree can be removed. In addition, pruning off of lower live branches reduces the infection target and thus may be useful as a control measure.

Pruning has little or no effect on ribes populations. It may be beneficial as a blister rust control measure by removing infected branches and leaf surface target for infection. White pine will not be pruned in stands outside of blister rust control units.

Thinning

The instructions and information on thinnings given in the general section of this handbook largely apply to white pine as well as other types. It should be kept in mind that thinning usually is one of the lowest priority stand improvement measures.

Thinnings, except when heavy, have little influence on blister rust control. Low thinnings, especially the heavier grades, are the least desirable from a ribes suppression standpoint because they may result in considerable opening of the forest cover and in mechanical disturbance of the forest floor. So much slash is created that some burning is usually necessary, which further stimulates ribes germination. Light thinnings do not create an appreciable ribes problem and may even aid ribes control through devitalization and futile germination of ribes seed. Crown and selection thinnings do not encourage ribes. The forest canopy, especially near the ground, is not greatly opened and little fire or mechanical disturbance to the ground cover results. Consequently, conditions favorable for ribes germination and development are not created. If the recommendations for thinning are followed, thinning will have little influence on blister rust control.

Improvement Cutting

Like thinnings, improvement cuttings can rarely be made in the white pine type with sale area betterment cooperative deposits because few stands suited to the practice are included within sale boundaries.

In pole stands, the main competitors of western white pine in the upper crown level are western larch and lodgepole pine. Other species which usually give some competition, and in some stands result in major competition, are western hemlock, grand fir, and Douglas-fir. Lodgepole pine, because of its rapid initial growth and widespread crown, competes seriously with white pine in the young pole stage.

But in the advanced pole stage white pine and other species overtake lodgepole pine in height. This, coupled with its relatively short life in the white pine type, results in its losing out in the stand by 100 years of age. Hence,

defective, unmerchantable trees of this species in the white pine type will not be disposed of by K-V funds; we will depend on the natural development of the stand to dispose of such trees. In some accessible pole stands, where white pine is dominated by lodgepole pine, the lodgepole can be removed in an improvement cutting, marketing the material as poles and pulpwood.

Western larch is a much more serious competitor of white pine than is lodgepole pine. It not only has the rapid initial growth of lodgepole pine but it grows to a much greater height and is longer lived. Western larch is a very intolerant tree; it must keep a full crown exposed to sunlight for rapid growth. Once larch falls behind in height growth and its crown becomes shaded, it loses out. White pine tends to catch up with larch in height sometime between 70 and 100 years of age. Though larch continues at an increasing disadvantage, there are usually sufficient superdominants of this species to maintain a place in the composition of the stand. As larch is seldom defective or unmerchantable because of limbiness, etc., K-V funds will not be used to dispose of trees of this species in pole stands. Once again, we will depend on regular sales procedure to remove trees of this species through improvement cuttings in pole stands. In some cases, larch poles can be removed, thus releasing white pine. Where such cuttings cannot be made, the larch will be left to go to maturity.

Douglas-fir, where it occurs, competes with white pine in the young pole stage, but tends to die out or fall behind in advanced pole stands. K-V funds will therefore not be used to dispose of trees of this species.

K-V deposits can be used to advantage to rid pole stands, when they are included in timber sale boundaries, of defective, unmerchantable grand fir and hemlock by poisoning or girdling. Grand fir competes with white pine throughout the life of the stand. Where this species is sound we will hope that eventually a pulpwood market will allow us to remove it in an improvement cutting. Where defective trees occur, K-V funds may be used. The same can be said of western hemlock. This species is not the aggressive competitor of white pine that the other species are, but on lower north slopes, especially, it is a serious competitor. Here, when defective, it may be killed by girdling or poisoning. When sound, it should be reserved for later sale as pulpwood or sawlogs.

The discussion on blister rust control and slash disposal under thinnings applies equally to improvement cuttings.

Ponderosa Pine Type

In contrast to the white pine type, greater flexibility is possible in the use of K-V deposits in the ponderosa pine type because of the presence of advance growth on sale areas.

Seedbed preparation and spot planting are important measures in this type because natural regeneration of ponderosa pine, following cutting, is frequently uncertain. Defective tree disposal, though important, is not the problem that it is in the white pine type.

Priority of Treatment in the Ponderosa Pine Type

Treatment	To be done with K-V funds	Priority of work
Cleaning	Frequently	1
Spot planting	"	2
Pruning	"	3
Liberation cuttings	Occasionally	4
Sanitation cuttings	"	5
Seedbed preparation	"	6
Improvement cuttings	Seldom	7
Thinning	"	8

The Type

The ponderosa pine type consists of stands in which 25 percent or more of the total net cubic volume is ponderosa pine. In western Montana, northern Idaho, and northeastern Washington, the type occurs in scattered bodies intermingled with other forest types. In this area the type occurs characteristically on south slopes and flats and other types occupy the more favorable sites. Throughout this territory its associates are principally Douglas-fir, lodgepole pine, grand fir, Engelmann spruce and alpine fir. Ponderosa pine frequently starts on the favorable sites after fires, but is crowded out by more tolerant species. Repeated fires over the centuries have favored ponderosa pine and have maintained the type over much of the region. With the exclusion of fire in recent years, young growth of ponderosa pine is being crowded out on many sites. This creates a problem which can best be remedied by measures which favor ponderosa pine.

In eastern Montana and on the Custer Forest in South Dakota the ponderosa pine type is different. There it occurs in pure stands, generally on the more favorable sites.

Where ponderosa pine occurs in mixture with other species, the relative desirability of species is as follows:

Ponderosa pine	Engelmann spruce
Western larch	Lodgepole pine
Douglas-fir	Grand fir
Western redcedar	Alpine fir

Cleaning or Weeding

Where timber sale areas are stocked with advance growth of ponderosa pine in competition with more tolerant associates, cleanings offer greater promise than any other treatment to improve the future crop. On many sale areas advance growth of ponderosa pine is hard-pressed by Douglas-fir and grand fir. These are the stands where cleaning or weeding can be of benefit in controlling composition of the stand to insure that ponderosa pine will be well represented in the future crop.

Douglas-fir competition can often be reduced without use of K-V funds by promoting the cutting of Christmas trees. Such cuttings should be encouraged, especially in selectively cut ponderosa pine stands having an understory of sapling-size Douglas-fir. Christmas tree cuttings are usually possible as many ponderosa stands operated on a short cutting cycle are accessible to Christmas tree yards.

One of the greatest dangers in cleaning ponderosa pine stands is the cutting of trees of too large a diameter. Only trees less than 3 or 4 inches in diameter should generally be cut in a cleaning. It is questionable if trees larger than this should be removed using K-V funds unless they are of poor quality or form. Where ponderosa pine is crowded by larger trees, the chance to release pine at a reasonable cost has been lost until such time as the trees can be utilized as pulpwood, pole, or post cutting. Where larger trees are to be removed because of defect, quality, or form, girdling or poisoning should be used rather than cutting.

Another factor which needs careful consideration is protection of the released stand from sun, wind, and snow damage. Frequently the ponderosa pines released may be rather weak, stringy, wisps of trees which need protection until they can develop heavier stems and crowns. In such stands girdling and poisoning of trees to be removed, even of rather small diameters, are recommended to provide standing stems to protect the reserved trees.

Seldom should a cleaning be undertaken unless at least 50 to 100 good ponderosa pine stems per acre can be released by the work. As to the upper limit, seldom should more than 1,000 stems be left per acre after cleaning.

Table 2 of the appendix gives suggestions for cleaning ponderosa pine stands.

Seldom is it worth while to clean ponderosa pine stands unless the overwood has largely been removed. Where moderate to dense overwood shade remains, ponderosa pine is at a disadvantage with its more tolerant associates even though a cleaning has placed it in a dominant position in the young stand.

Spot Planting

Natural regeneration is frequently so uncertain and slow following cutting in the ponderosa pine type that many areas should be spot planted to insure prompt and full restocking. Therefore, spot planting is given a high priority as a K-V measure.

Several precautions should be observed in spot planting. Planting must be done with care. Sites should be carefully selected. Areas which are unstocked because of rock outcrop or heavy, deciduous growth should be avoided. Site preparation by disking or furrowing may be necessary for planting to be successful. Do not plant unless the planted trees have a reasonable chance for survival and good development. Only ponderosa pine will be planted.

Pruning

Timber sale areas in the ponderosa pine type frequently contain pole-size ponderosa pine trees which will be benefited by pruning. Consequently, pruning is a high-priority K-V measure. Only ponderosa pine trees will be pruned.

The number of trees to prune per acre may vary depending on the stocking of ponderosa pine. In some areas it may be impossible to prune more than 50 trees per acre. Seldom should pruning be undertaken, however, in stands where less than 50 trees per acre are suited to pruning as costs become excessive in sparsely stocked stands. Not more than 200 trees per acre should be pruned. The actual number of crop trees selected should depend upon being able to meet the requirements for a good crop tree and not upon any predetermined objective as to numbers.

Pruning lends itself ideally to contract work. This method should be fully explored wherever possible. Included in the appendix is a sample contract used by Region Six.

Liberation Cutting

Many cut-over areas in the ponderosa pine type have a residual stand, frequently of low or negative value trees, with understory of reproduction or advance growth. On these cut-over areas ponderosa pine is at a disadvantage because it cannot compete successfully with its more tolerant associates under the shade of residual trees. Liberation cuttings are sometimes needed to release the young growth, followed by cleanings to improve the composition of the young stand.

The increasing use of light, partial cuttings in the ponderosa pine type will aggravate this situation. Tolerant species will be favored over ponderosa pine in the young stand, especially on the favorable sites. However, as these residual stands will contain a much higher proportion of valuable trees than many of the present cut-over areas, the chance of making a liberation cutting through regular sales procedure will be much greater.

It is not meant to overemphasize the importance of liberation cuttings. The advantage of partial cutting may far outweigh the adverse effects it may have on the new stand. At the same time, these effects should be recognized and liberation cuttings should be made when they fit in with management objectives.

Whenever possible, administrative use will be used to make liberation cuttings. If the residual trees are sound, and of good form, but unmerchantable, they will be reserved until such time as they become merchantable even though this may mean losing the ponderosa pine in the young stand.

The only trees which will be removed in a liberation cutting are trees of relatively small diameters and those hopelessly unmerchantable because of defect, limbiness, or poor form. It will be possible to dispose of these with K-V funds only when such funds are obtained through sale of other trees in the stand. Girdling or poisoning (poisoning preferred) will be used to dispose of these unmerchantable stems.

No trees will be cut, girdled, or poisoned if such work will result in a build-up of insects which might endanger surrounding reserved trees.

Care must be taken also not to create an undue fire hazard. Not more than 15 to 20 trees per acre should be killed by girdling or poisoning.

Care in logging must be observed when making liberation cuttings to protect the young growth from damage. Care in felling, skidding, and disposal of slash is especially important.

Sanitation Cuttings

On timber sale areas containing unmerchantable, mistletoe-infected trees, it may be desirable to remove these trees through use of K-V funds to prevent young growth from becoming infected and to rid the area of worthless trees and thus make room for new growth.

The methods and precautions given in the preceding section under liberation cuttings apply equally well for sanitation cuttings.

Improvement Cuttings

Although timber sale areas in the ponderosa pine type occasionally are stocked with young growth of pole size, seldom will K-V funds be used in making improvement cuttings in these young stands. The general policy will be to depend on administrative use sales to make improvement cuttings at such time as the products of cutting become merchantable. An exception to this policy will be pole stands within the sale area boundaries which have trees unmerchantable because of excessive crook, limbiness, or defect. In this special case K-V funds may be used to rid the stand of these trees by poisoning or girdling.

Douglas-fir and grand fir will be the usual species removed in improvement cuttings. Occasionally lodgepole pine, Engelmann spruce, alpine fir, and porcupine-damaged ponderosa pine may be removed.

Thinning

Seldom will stands be thinned in the ponderosa pine type through the use of K-V funds. Thinnings will be delayed until markets develop for the materials removed in the thinning operation.

This does not mean that thinnings are not a desirable measure. Thinnings definitely are desirable and needed. Ponderosa pine responds especially well to release and is benefited greatly by thinnings. Foresters are urged to thin in ponderosa pine wherever possible to remove such products as fuelwood, posts and pulpwood.

An exception to the policy of not using K-V funds for thinning will be experimental trials of fire and machinery to break up dense thickets of reproduction on timber sale areas. The forests are encouraged to experiment with fire and mechanical methods to reduce the number of stems and overcome stagnation of the stand.

Seedbed Preparation

Seedbed preparation should have a higher priority as a sale area betterment measure, but it is placed low on the list because positive methods have not yet been fully developed. The need is great in the ponderosa pine type for a method which will result in prompt and full regeneration. Seedbed preparation may aid in obtaining regeneration.

Forests are encouraged to use K-V funds in the ponderosa pine type on experiments of seedbed preparation. Such experiments should be modest in size and methods should be used on sites which offer real hope of success.

Suggested methods which may prove successful are burning, ground scarification by ripping, harrowing, disking, and furrowing. The need is for cheap, yet effective, methods.

Western Larch-Douglas-Fir Type

The larch-fir type does not offer the wide range in possibilities for sale area betterment and stand improvement as the white and ponderosa pine types. Pruning does not have the possibilities that it does with white and ponderosa pine because species in the larch-fir type are not as high-quality woods and do not have as great a spread between select and common grades of lumber. However, pruning larch for veneer peeler logs is a real possibility which should be carefully considered.

There are certain measures, however, which should be undertaken with K-V funds whenever possible. Sale areas which do not regenerate naturally at a reasonable rate should be spot planted. Overwood stands suppressing young growth should be removed in liberation cuttings when this fits in with management objectives. Unmerchantable trees should be removed to open the space for vigorous young growth. And thinning of overdense young stands by machine methods should be tried experimentally.

The following table lists the measures which may have a place in the use of K-V funds and the general priority of work.

Priority of Treatment in the Western Larch-Douglas-Fir Type

Treatment	To be done with K-V funds	Priority of work
Spot planting	Frequently	1
Seedbed preparation	"	2
Liberation cutting	"	3
Cleaning	Occasionally	4
Prescribed burning	"	5
Sanitation cutting	"	6
Pruning	Experimentally	7
Thinning	"	8

The Type

The characteristic species of the larch-Douglas-fir type are western larch and Douglas-fir. Practically all the other timber species of the region, western white pine, ponderosa pine, Engelmann spruce, grand fir, western hemlock, lodgepole pine, western redcedar, and alpine fir occur in mixtures in various degrees, but the typical stand is nearly pure larch and Douglas-fir.

The type owes its maintenance to fire. Western larch is an intolerant but long-lived species which is replaced by the more tolerant Douglas-fir if the stand develops naturally without fire. Douglas-fir is probably the climax species over much of the range of the type, especially where the type meets with the ponderosa pine type. Where the type meets with the Engelmann spruce type at higher elevations, Engelmann spruce and alpine fir will replace both larch and Douglas-fir as they are more tolerant. Where the type meets with the white pine type, grand fir, western hemlock, and western redcedar are the climax species. As in many other types, fire has prevented the stands from reaching their climax.

Like all other types, the requirements of individual species must be kept in mind in all cutting and stand improvement operations. Partial cuttings tend to eliminate larch from future stands. And in some stands such cuttings will favor species which are more tolerant than Douglas-fir.

Spot Planting

K-V deposits may be used in the larch-Douglas-fir type for the planting of areas within timber sales which do not regenerate naturally within a reasonable period of time. The difficulty of such work is knowing in advance how large a K-V collection to make for this purpose. About the only guide that can be given is to observe older sale areas and to judge from them how much spot planting may be needed.

Western larch will be the usual species to plant. Engelmann spruce may be planted occasionally on the more cool, moist sites, and ponderosa pine on the dryer, warmer sites.

Site preparation will be needed on some areas for successful spot planting. As methods for site preparation are largely still experimental, forests are encouraged to test methods such as furrowing and soil scarification by ripping, disking, and burning.

Do not plant unless the planted trees have a reasonable chance for survival. This means careful selection of sites and avoidance of rock outcrops and brushy sites.

Seedbed Preparation

Observations of cut-over areas in the larch-fir type invariably show that soil disturbance results in the establishment of reproduction. Skid roads and other portions of forest floor torn up during logging are usually satisfactorily stocked with larch and spruce. Intervening ground, however, is usually stocked with luxuriant growth of grass and shrubs. These areas may restock very slowly and the more tolerant, undesirable firs will probably be the only species able to fight their way through. The foregoing indications of the advantages of soil scarification merit rating seedbed preparation as a high-priority sale area betterment practice. Methods of seedbed preparation include ripping, furrowing and disking. The Experiment Station recently purchased an Athens disk and will use it during 1949 in the recently cut-over larch-fir type on the Coram Experimental Forest.

Liberation Cutting

Release of reproduction from suppression by overtopping residual trees is frequently needed on timber sale areas in the larch-Douglas-fir type. At times this reproduction is present as advance growth at the time of logging and at other times it has become established following cutting. Where larch is well represented in the young stand, liberation cutting is especially needed if this species is to be represented in the future crop. Larch is intolerant and cannot compete with its more tolerant associates under moderate to dense shade.

Cleaning or Weeding

In stands having an advanced growth of suppressed alpine fir in the understory in sufficient numbers to prevent the establishment of a predominant percentage of larch and Douglas-fir following cutting, the alpine fir 2 inches d.b.h. and smaller should be weeded out in a cleaning operation. Attention should first be given to the best sites and the more accessible areas. As a general rule, it will be impractical to remove alpine fir over 2 inches d.b.h. in the cleaning operation. These larger trees should be left to grow and may be removed at some future time if and when a pulpwood market develops. Expenditures of K-V money in the above cleaning operations should be held to a reasonable amount and probably on an average per acre basis should not exceed one-half the cost of planting unless there exist extenuating facts which will support more intensive and costly treatment.

A good time to do this work is after logging slash is piled and before slash is burned. The alpine fir cut can be placed on brush piles where convenient and disposed of easily.

Prescribed Burning

Larch-fir is a fire type and we have innumerable examples of excellent regeneration on natural burns. It follows that we can use fire in seedbed preparation to secure prompt establishment of a new stand. We need to do more experimenting to perfect a technique to accomplish prescribed burning on many larch-fir cut-overs. On many sales live cull larch trees are adequate for seed source and have fire-insurance value, accordingly, do not cut live cull larch.

Sanitation Cutting

On sale areas containing unmerchantable, mistletoe-infected trees, it may be desirable to cut or kill these trees by use of K-V funds to prevent young growth from becoming infected and to rid the areas of worthless trees and make room for new growth.

Pruning

Forests are encouraged to prune western larch, looking to a future of such trees as veneer peeler logs. The discussion for pruning in the ponderosa pine type applies equally well to the larch-Douglas-fir type.

Do not prune larch stems unless they have plenty of room for growth. Larch tends to stagnate in dense stands and does not recover well when released after stagnation.

Thinning

Seldom will stands be thinned in the larch-Douglas-fir type through the use of K-V deposits. Thinnings will be delayed until markets develop for the material removed in thinning; they can then be made under regular sales procedure.

This in no way minimizes the importance of thinning. Western larch stands especially need to be thinned frequently to obtain the maximum growth. When larch is grown in dense stands, it tends to stagnate at an early age because it cannot maintain a full crown. Only by keeping larch well spaced to maintain full, long crowns will this species maintain a good rate of growth. Once its crown has been crowded to a mere wisp at the top and the tree has stagnated, it is unable to respond to release. In fact, larch shows less response to release after stagnation than any other species in this region.

An exception to the policy not to thin with K-V funds will be the use of such funds for experimental thinning of dense thickets, especially alpine and Douglas-fir on timber sale areas by tractors or other machinery. Forests are encouraged to make such experiments but they should not be too extensive and must have a positive hope of success.

Christmas Tree Business

Harvesting of Christmas trees provides a means of accomplishing a lot of good stand improvement work in parts of the larch-fir and ponderosa types. Ordinarily intensive Christmas tree culture is not advocated on Government lands as there is a lot of private land devoted to growing of Christmas trees. In planning Christmas tree sales the following priorities should be kept in mind as to desirability of selling Christmas trees.

1. Areas where the cutting of Christmas trees will improve stand of commercial species.

2. Areas where the Christmas tree business has, to some extent, resulted in an expectation of part-time employment by local landowners.

3. Areas to be managed primarily for production of Christmas trees. Guard against competing with private lands.

K-V collections from Christmas tree sales should be made only for areas to be managed primarily for production of Christmas trees or for spot planting of ponderosa pine on good sites where Christmas trees will be marked for cutting to insure limited competition from Douglas-fir.

Stand improvement and sale area betterment measures for areas to be managed primarily for production of Christmas trees follow.

Christmas Tree Culture

Christmas tree culture comprises a number of stand improvement measures including cleaning, thinning, pruning, liberation cuttings, stump culture, and spot planting.

Cleaning. Some Christmas tree stands will be benefited by a cleaning to remove trees and shrubs such as western larch, lodgepole pine, birch, serviceberry, willow, and maple which interfere with the development of Douglas-fir Christmas trees.

As these species grow more rapidly in the open than Douglas-fir they frequently overtop it and interfere with its development. Where this occurs, K-V funds collected from sale of Christmas trees or other products from the area may be used to accomplish this work.

Cleanings should be made when the stand is young and the work can be cheaply accomplished, and then very carefully and only when needed.

Thinning. Thinning has for its purpose the regulation of spacing in crowded stands. Thinning in Christmas tree stands should accomplish proper vertical as well as horizontal spacing. Proper vertical spacing means maintaining trees of differing heights in the same stand. Hence, the removal of taller trees will release smaller trees for future cuts. Thinning is often accomplished by the harvesting operation when carefully done. However, some additional thinning is frequently necessary to provide space for good crown development. Too much thinning may subject the reserved trees to wind and snow damage. There is no set rule for proper spacing. The larger trees that are nearing Christmas tree size need sufficient room for growth of dense symmetrical crowns. Smaller trees that are being held for later development after harvesting of their larger neighbors can temporarily be left rather crowded and shaded. Thinning must be done carefully or the stand will be harmed rather than improved. A good rule is to thin lightly and often.

Pruning. Pruning of Christmas trees is one of the most debated measures. Some growers believe that pruning retards height growth, thus forcing the top to develop a thicker, better-foliaged crown of deeper color. A few believe that pruning does not have much value. Studies are now under way by the Experiment Station to determine the effects of pruning. It seems likely that rather severe pruning or slashing the bark from two sides of a tree will stunt height growth and result in a denser top. Light to moderate pruning probably does not affect top development a great deal, but it may give more space for crown development of other trees.

No pruning through use of K-V funds will be done, except experimentally, until research has determined the value of pruning and how to prune.

Liberation Cutting. Liberation cutting removes trees which have grown out of merchantable size for Christmas trees, and other overwood trees not needed for seed. Such cuttings are needed to hold the stand for Christmas tree production. Overwood trees should be worked out for such products as fuelwood, posts, corral poles, and pulpwood. Some overwood trees are unmerchantable because of rot, crook, or other defect. These should be felled, girdled or poisoned to give space to young trees beneath.

Stump Culture. Stump culture is one of the most interesting practices in the growing of Christmas trees. By this means one or more trees are grown from the stumps of harvested trees. These new trees originate either from branches which turn up and develop into new leaders, or from adventitious buds. Stump culture results in faster growth because a well-developed system is available to feed the new crown, and it relieves the grower from complete dependency on the slower and less certain processes of natural or artificial regeneration. The practice may be very detrimental if done carelessly and if stump branches are left untended. But when carefully applied, stump culture has a beneficial and definite place in the growing of Christmas trees.

Stump culture is best practiced where the tree is growing alone in an opening. Through proper pruning, successive branches can be developed into well-formed Christmas trees. In this way the opening continues to produce trees until such time as regeneration can become established.

Stump culture is most harmful when attempted in thickets. Here the branches bush out and form a "wolf tree" which so crowds its neighbors that none can develop properly. Stumps in thickets should usually be killed. Untended living stumps usually develop two or more leaders which result in the growth of forked trees.

To be successful, stump culture requires careful attention. Follow-up in the form of one, two, or three prunings is necessary to control and train the stump branches so they will not interfere with each other but will form successive trees. Unless this follow-up can be made, it is usually better practice to kill the stump at the time of cutting the original tree.

Stump culture is still in the experimental stage. However, K-V funds may be used on a modest scale to develop this measure.

Planting. Frequently, when seed trees are not present, or for other reasons, openings which do not regenerate very rapidly occur in Christmas tree stands. Many of these need to be forested artificially for maximum production of Christmas trees. Planting of young trees is the most successful artificial method. Planting stock of Douglas-fir which has been in the seedbed 2 years and in the transplant bed 2 years has proved satisfactory for this purpose. This work may be financed from K-V funds.

Lodgepole Pine Type

Stand improvement and sale area betterment techniques are largely in the experimental stage in the lodgepole pine type. Forests are encouraged to test experimentally various measures in order to build knowledge and gain experience. However, only methods which have some hope of success should be tested.

The following measures are suggested for the present.

Priority of Treatment in the Lodgepole Pine Type

Treatment	To be done with K-V funds	Priority of work
Sanitation cuttings	Frequently	1
Planting	Occasionally	2
Thinning	Experimentally	3
Cleaning	"	4

The Type

The lodgepole pine type occurs as a fire and logging type throughout Region One. Thus, lodgepole stands are characteristically even-aged. Occasionally, however, many-aged and all-aged stands are to be found. These have usually resulted from young growth becoming established in an even-aged stand which has been opened by beetles or some other agent. Great density, frequently to the point of stagnation is a characteristic of lodgepole stands.

The ecologic trend of the type varies, depending on the locality and site. Where lodgepole stands occur as a fire type within the white pine type, they may have present all the associates of that type in varying proportions. In the long run, lodgepole is crowded out by other species and the climax association is grand fir-western hemlock-western redcedar. In the ponderosa pine type lodgepole is crowded out by ponderosa pine on the dryer sites where that species is climax, by Douglas-fir and grand fir on cooler and moister sites. In the larch-fir type, it is replaced by Douglas-fir, Engelmann spruce and alpine fir. In the subalpine type it is eventually crowded out by Engelmann spruce and alpine fir with alpine fir the probable climax.

As a stable type, lodgepole pine comes into its own east of the Continental Divide. Here it occurs in pure stands over extensive areas. Engelmann spruce and alpine fir often intermingle at higher elevations and Douglas-fir on the more favorable sites at lower levels. Although it is doubtful if lodgepole pine is truly the climax species even in this area, for all practical purposes it may be considered climax in many of the pure stands because of the lack of seed source of other species. Where it occurs in mixtures with Douglas-fir, Engelmann spruce, and alpine fir, these species will replace lodgepole pine in the long run. Alpine fir, because of its great tolerance, is probably the climax species over much of the area.

Lodgepole pine is relatively short lived. In the western part of the region it attains maturity between 70 and 100 years. In the central and eastern parts the species frequently attains a somewhat greater age.

Sanitation Cuttings

Cull trees on timber sale areas, especially on clear-cut areas, should be felled or poisoned. Many of these are mistletoe infected and need to be removed to prevent young growth from becoming infected. Others may be stem cankered or defective because of some other cause, and need to be removed to make room for new growth. Poisoning of such worthless material is probably the preferred method where it does not conflict with fire control or aesthetic considerations.

In young stands it may be desirable to fell young trees infected with stem cankers to favor sound competitors. Cutting or pruning reproduction or small saplings infected with mistletoe should be on an experimental basis only.

Planting

Openings created by logging operations which do not regenerate naturally within a reasonable time may merit spot planting. In the event creek bottoms must be clear cut they should be planted promptly. Good sites on south slopes which do not regenerate naturally should also be planted.

Thinning

Thinning of any kind in any stand should be on an experimental basis only until methods and results are better understood. Experimental thinning of dense, young stands by use of tractors or other equipment is encouraged.

Cleaning or Weeding

Occasionally lodgepole stands that have been opened up by insect attacks or other causes support an understory containing a preponderance of alpine fir. On sites III or better containing advanced growth of suppressed alpine fir in sufficient numbers to prevent the establishment and growth of lodgepole following cutting, the alpine fir 2 inches d.b.h. and smaller should be weeded out on an experimental basis.

Engelmann Spruce Type

Marking methods and stand treatment in the Engelmann spruce type are still in the experimental stage. As in the lodgepole pine type, foresters are encouraged to test various measures experimentally. However, only methods which have some hope of success should be tested.

Priority of Treatment in the Engelmann Spruce Type

Treatment	To be done with K-V funds	Priority of work
Planting	Frequently	1
Seedbed preparation	"	2
Sanitation cutting	Occasionally	3
Liberation cutting	"	4

The Type

The Engelmann spruce type occurs at higher elevations in both Idaho and Montana. Characteristic species are Engelmann spruce, alpine fir, Douglas-fir, and lodgepole pine. In the western part of the region, western white pine, whitebark pine, grand fir and mountain hemlock may also occur in varying proportions. The Engelmann spruce type of the divide ridges and eastern Montana may have whitebark pine and white spruce present. Engelmann spruce is only occasionally found in pure stands; alpine fir is almost invariably present.

The Engelmann spruce type occurs at its lower limits along cool, moist stream courses. At higher elevations, although it develops best in protected coves and other cool, moist, protected sites, it spreads to most any site.

Although the Engelmann spruce type is most commonly a fire type, uneven-aged stands are probably more common because of the species involved, and the preference of the type for moist situations which are not as subject to fires as are the dryer sites.

Although both Engelmann spruce and alpine fir are tolerant species, alpine fir is the more tolerant of the two and hence is probably the climax species over much of the spruce type. An understory, mainly of alpine fir, usually is present. Both species withstand shade well and respond readily when released.

The major species of the Engelmann spruce type are not wind-firm. This characteristic must constantly be kept in mind when planning cutting or stand improvement practices. Opening dense stands too greatly will result in excessive losses from windthrow.

The Engelmann spruce type is of especial importance in the protection of watersheds. This fact must also be considered in developing all cutting and stand improvement plans for the type.

The relative desirability of species in the Engelmann spruce type is approximately as follows, listing from most desirable to least desirable: Engelmann spruce, alpine fir, lodgepole pine, Douglas-fir.

Planting

Planting ranks high as a K-V measure in the Engelmann spruce type. Prescribed broadcast burned areas in this type will be planted to Engelmann spruce. Sale areas where natural regeneration has been depended on but which do not fully restock in a reasonable period should be spot planted to insure full restocking.

Do not plant areas which are unstocked because of extreme brush competition or rock outcrop. On good sites brush competition may merit chemical control. Do not plant unless the trees have a reasonable chance for survival and development.

Seedbed Preparation

Methods which will encourage and insure a new crop of Engelmann spruce are badly needed. Seedbed preparation should have the high priority and be tried experimentally until such time as proved methods have been developed.

Some of the factors which make seedbed preparation so badly needed are: (1) The great amount of heavy and tall brush of menzesia, huckleberry, alder and mountain-ash which retard and frequently prevent the establishment of a forest stand. Chemical methods are advocated. (2) The abundance of understory alpine fir which needs to be destroyed if spruce is to be favored in the new stand. (3) The lack of wind-firmness of spruce and alpine fir which points to a clear-cutting method and the possible use of prescribed broadcast burning as a method of destroying slash, brush, and understory alpine fir, preparatory to planting.

Methods of seedbed preparation which should be tested are burning and scarification by machinery such as ripping, disking, and furrowing.

Sanitation Cuttings

Sale areas containing residual trees unmerchantable because of rot or other defect should occasionally be treated through use of K-V deposits to rid the area of worthless trees and to make room for new growth.

Poisoning will be used to dispose of these unmerchantable trees.

Care must be taken not to create an undue fire hazard. Not more than 15 trees per acre should be killed by poisoning.

Care must also be taken not to create an insect problem. Neither felling nor girdling are recommended because of this danger.

Liberation Cuttings

Some areas in the Engelmann spruce type have been partially cut, leaving a residual stand of low-value or negative-value trees, which are often subject to losses by windthrow. Such stands have been opened up sufficiently for reproduction to become established or advance growth was already present at the time of cutting. On these areas young growth of Engelmann spruce is at a disadvantage because it cannot compete successfully with alpine fir. Liberation cuttings are sometimes needed to correct this condition.

Wherever possible, administrative use sales should be used to make liberation cuttings. If the residual trees are sound, and of good form, they will be reserved until such time as they become merchantable, even though this may mean losing Engelmann spruce in the young stand beneath.

The only trees which will be removed in a liberation cutting financed from K-V deposits are trees of relatively small diameters and those hopelessly unmerchantable because of defect, limbiness, or poor form. Poisoning will be the preferred method of disposing of those trees, observing the precautions given under the preceding section "Sanitation Cuttings."

East Side Douglas-Fir Type

Sale area betterment and stand improvement suggestions are discussed in form M-1022-R1, Management Instructions for the Douglas-Fir Type East of the Continental Divide.

VIII. APPENDIX

S
STAND IMPROVEMENT

M-1014-R1 (Rev. May 1949)

PLAN AND REPORT - STAND IMPROVEMENT PROJECT
(Reference S.A.B. and Stand Improvement Handbook, page 19.)

Use this form for both plan and report for stand improvement projects. Cross out words not applicable. Prepare in duplicate - one copy to Experiment Station, one copy for forest files.

GENERAL

National forest _____ Date of work _____

Acreage to be or treated _____

Type of work _____

Kind of labor and funds to be or used _____

Location _____
(Drainage) (Section, township, range)

Major topographic and drainage features _____

_____

_____

History of area _____
(Logging, fire, insect infestations, previous stand improve-

_____
ment work, blister rust control situation, etc. Give dates.)

_____

_____

_____

Map (to be attached to report)

Scale to be not less than 4 inches to the mile, larger if possible.

Show on map:

- Legal subdivisions
- Drainage
- Land status
- Found corners
- Improvements, such as main roads, logging roads, trails, etc.
- Forest types
- Individual sale area boundaries
- Boundaries of areas to be or treated
- Boundaries of areas not to be or treated
- Date of work
- Order of work
- Location of sample transects or plots
- Sources of data and probable accuracy

SILVICULTURAL DESCRIPTION OF STAND

Forest type _____
(Western white pine, ponderosa pine, etc.)

Age _____
(If more than one age class, give age of each)

Composition _____
(Give basal area composition in percent by species)

_____

_____

_____

Condition _____
(Thrifty, decadent, snow damaged, etc.)

_____

_____

TREATMENT

Purpose _____
(To improve composition, stimulate growth, remove defective trees, etc.)

_____

_____

_____

Nature of work _____
(Describe just what is to be or was done)

_____

_____

_____

_____

_____

_____

Date work is to be or was begun _____

Date work is to be or was completed _____

_____

_____
(Specify if work was done on several dates)

TREATMENT (cont.)

Stand before treatment, summary

Species	Number live trees per acre	Average diameter (inches)	Basal area per acre (sq. ft.)			
Totals						

Stand after treatment, summary

Species	Number live trees per acre	Average diameter (inches)	Basal area per acre (sq. ft.)			
Totals						

Mortality since treatment _____

(Amount and cause)

TREATMENT (cont.)

Slash disposal and fire protection:

When done _____
(Dates)

_____

Methods _____
(Pile in summer and burn in fall, progressive pile and burn, dragging

_____
slash to selected spots, clean-up along roads and trails only, etc.)

_____

_____

_____

_____

Any special features:

METHODS AND COSTS

Marking _____
(Technique - done by crew or foreman)

_____

_____

Supervision and training _____

_____

_____

Crew organization _____
(Size of crew, order of work, etc.)

_____

_____

Equipment _____
(Axes, saws, nippers, giving size, number, etc.)

_____

METHODS AND COSTS (cont.)

Any special technique _____

_____

_____

Output data

Job	Effective man-days per acre	

Remarks _____

_____

_____

_____

_____

SOURCES OF DATA

Areas _____

Methods and costs _____

Stand tables _____

Other _____

_____

_____

GENERAL COMMENTS

PERSONAL EVALUATION OF PROJECT

What is your reaction to the project?

Has the work accomplished the purposes?

Do you think the work could have been done more effectively? If so, how?

Summary evaluation:

Date _____

Signed _____

Approved _____

S
STAND IMPROVEMENT

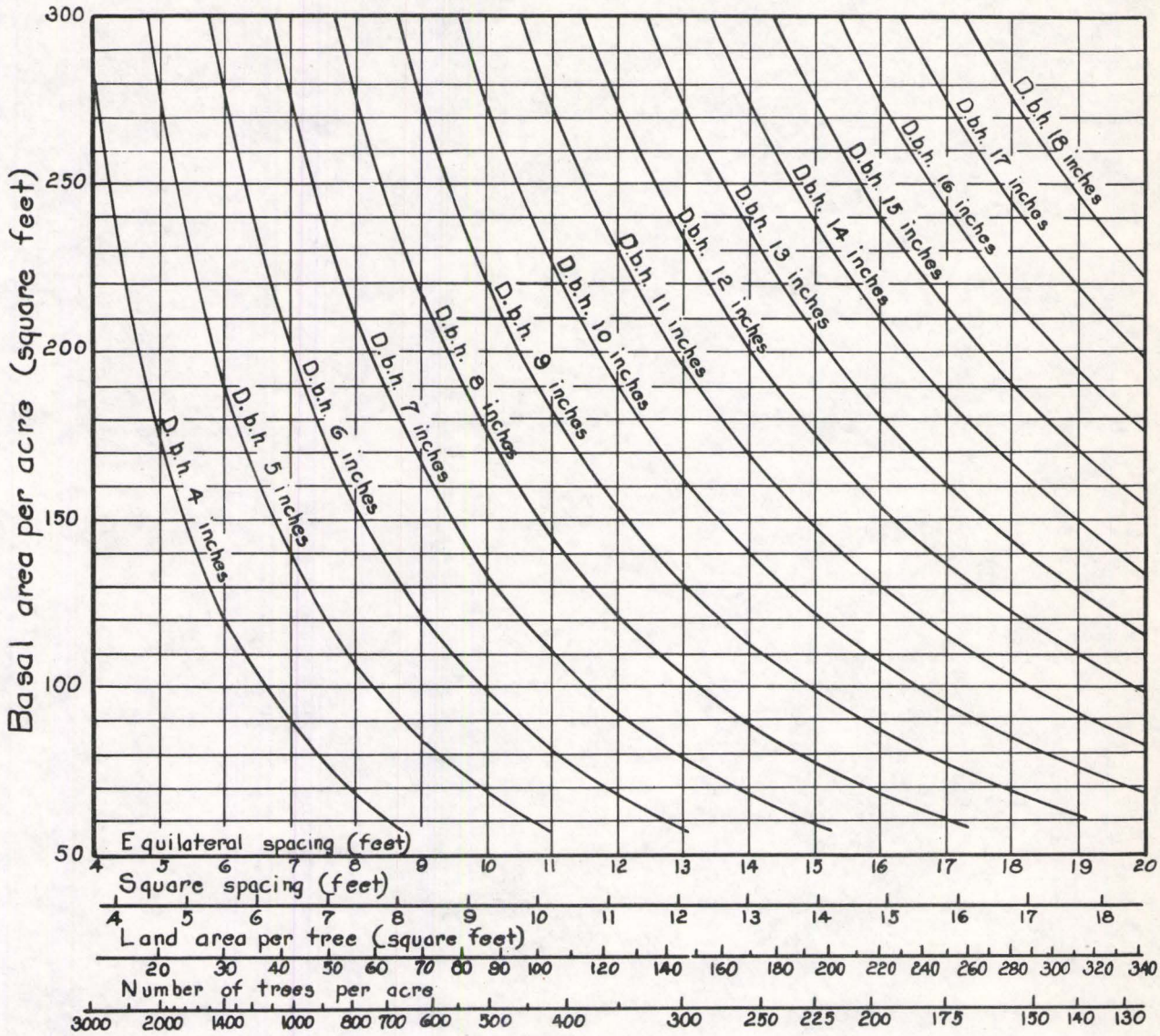
M-1070-R1

CUMULATIVE SALE AREA BETTERMENT SUMMARY

(For regional forester's and Chief's sales, due February 15 in regional office.)
(Ranger's reports due in supervisor's office February 1.)
(Reference S.A.B. and Stand Improvement Handbook, page 20.)

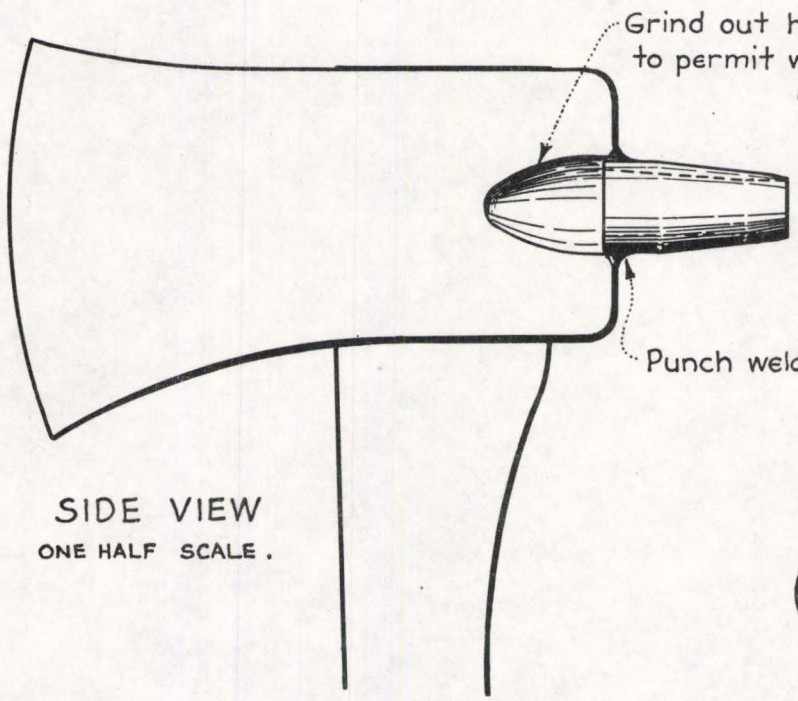
Forest _____ Ranger District _____ Sale Designation _____

Calendar year	Dollars of K-V earned	Dollars allotted by supervisor	Expenditures		Acres or amount treated	Memorandum attached	Initial and date
			Dollars used	Man-days		Yes or no	

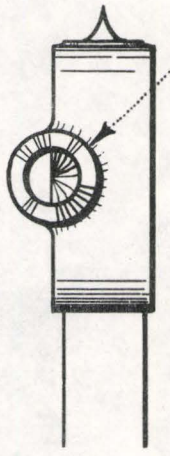

Basal area per acre (square feet)
300
250
200
150
100
50
D.b.h. 4 inches
D.b.h. 5 inches
D.b.h. 6 inches
D.b.h. 7 inches
D.b.h. 8 inches
D.b.h. 9 inches
D.b.h. 10 inches
D.b.h. 11 inches
D.b.h. 12 inches
D.b.h. 13 inches
D.b.h. 14 inches
D.b.h. 15 inches
D.b.h. 16 inches
D.b.h. 17 inches
D.b.h. 18 inches
Equilateral spacing (feet)
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Square spacing (feet)
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Land area per tree (square feet)
20 30 40 50 60 70 80 90 100 120 140 160 180 200 220 240 260 280 300 320 340
Number of trees per acre
3000 2000 1400 1000 800 700 600 500 400 300 250 225 200 175 150 140 130

SPACING DIAGRAM

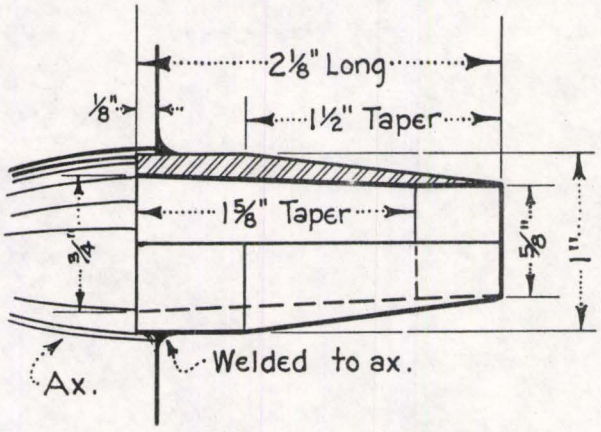
(Prepared by K. P. Davis)



SIDE VIEW
ONE HALF SCALE.



END VIEW



QUARTER SECTION OF PUNCH

FULL SCALE

Note:
Made of steel, or steel bushing.
For thick barked trees, use a longer punch.

AX PUNCH
USED IN
POISONING TREES

USFS. REGION 4. JAN. 1945. PSB.

U. S. Standard Form 33 (Revised)
Approved by the Secretary of the Treasury
January 17, 1939

SAMPLE BID FOR STAND IMPROVEMENT WORK

Invitation No. _____

Contract No. _____

INVITATION, BID, AND ACCEPTANCE

(SHORT FORM CONTRACT)

U. S. Dept. of Agriculture Forest Service
(Department or establishment)

(Office or station)

(Address)

(Date)

INVITATION

Sealed bids, in _____ subject to the conditions on the reverse hereof, will be received at this office until _____ o'clock _____ m., _____, and then publicly opened, for furnishing the following supplies, and/or services, for delivery at _____.

(Name) (Title)

ITEM No.	ARTICLES OR SERVICES	QUANTITY	UNIT	UNIT PRICE	AMOUNT Dollars	AMOUNT Cents
	1. Furnish all tools, equipment, transportation and labor, except as specified below, for pruning and releasing all marked trees in areas of second growth within the following described lands as shown on the attached map:					
	_____ Sec. _____ Twp. ___ Rge. ___ Payment will be made on the basis of number of trees satisfactorily treated as determined by the forest supervisor or his authorized representative. All pruning and release to be done in accordance with attached specifications which are made a part of this bid. Special Forest Service pruning saws will be furnished by the Government. The job will consist of the following units:					
1.	Prune to 18-foot height	1,000	each			
2.	Prune to 14-foot height	2,000	each			
3.	Prune to 10-foot height	1,500	each			
4.	Release	1,000	each			
	Bid price for total job					

BID

_____ (Date)

In compliance with the above invitation for bids, and subject to all the conditions thereof, the undersigned offers, and agrees, if this bid be accepted within _____ calendar days from the date of the opening, to furnish any or all of the items upon which prices are quoted, at the price set opposite each item, delivered at the point(s) as specified and, unless otherwise specified within _____ calendar days after receipt of order.

Discounts will be allowed for payment as follows: _____ percent 10 calendar days; _____ percent 20 calendar days; _____ percent 30 calendar days.

Bidder _____ Address _____

By _____ Title _____
(Signature of person authorized to sign this bid)

ACCEPTANCE BY THE GOVERNMENT

_____ (Date)

Accepted as to items numbered _____

Name _____ Title _____

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(OVER)

STANDARD GOVERNMENT FORM OF CONTINUATION SCHEDULE FOR STANDARD FORM 31 OR 33

Bidder must show unit prices and total for job. Bids for less than total job not acceptable. Acceptance will be on the basis of the lowest bid for the total job. Each tree to be worked will be marked by the Forest Service in advance to indicate which of the above four treatments it is to receive.

2. Work to be started within ____ days and carried to completion within ____ days.

3. Partial payments may be made monthly for 90 percent of the completed work accepted as satisfactory. Final and complete payment including the 10 percent withheld from partial payment will be made after completion of the work and acceptance of the entire job by the forest supervisor or his representative.

Acceptance will be determined by inspection of at least 20 percent of the marked trees. Inspection will be on representative cross sections of the treated area and will consist of examining the trees for (1) conformance with height of pruning, (2) release, as designated by the mark on the tree, (3) closeness of pruning, (4) adequacy of release, and (5) disposal of slash as described in the specifications attached hereto. A pruning operation will be checked for compliance with items 1, 3 and 5 mentioned in this paragraph. A release operation will be checked for compliance with items 2, 4 and 5 mentioned in this paragraph. A combination pruning and release operation will be checked for compliance with all five points.

Nonconformance with any one of the above five designated treatments or specifications will classify a tree as unsatisfactorily treated.

The total number of trees to be accepted for payment in each item of the contract will be reduced by the percentage of examined trees found to be unsatisfactory for that treatment. Payment will be made only for the number of trees thus arrived at. "For example, if 100 trees marked for 18-foot pruning are examined and 4 are found to be unsatisfactory, payment will be made for 96 percent of the trees completed for 18-foot pruning. If, in addition, 50 trees marked for release are examined and all are found to be satisfactory, all trees completed for that treatment will be paid for." Improper disposal of slash from pruning operations will class a tree as unsatisfactorily pruned. Improper disposal of slash from a release operation will class a tree as unsatisfactorily released. If the tree receives both treatments and slash disposal only is unsatisfactory, the tree will be counted as unsatisfactory for both pruning and release.

Inspections will be made at the request of the contractor and must be made before any payment is approved.

The results of an inspection made for purpose of payment will apply only to the trees in a completed work area for which payment is to be made. Form AD-238, "General Conditions Applicable to Service Contracts," is made a part of this bid.

SPECIFICATIONS FOR STAND IMPROVEMENT WORK TO ACCOMPANY BID FORM 33

The work will consist of pruning and releasing crop trees. Each crop tree to be treated will be marked by the Forest Service with paint or by other means to designate the type of treatment it is to receive.

I. Method of Pruning

Dead branches of Douglas-fir may be pruned off with a club similar to the "Hebo Pruning Club."

Live branches of Douglas-fir and all branches of other species must be pruned off with saws.

II. Height of Pruning

All branches and stubs of branches will be removed to the height designated by the mark on the tree. Measurement will be from the high side of the slope where marked trees are growing on hillsides.

III. Closeness of Pruning

Branches and stubs of branches removed with a club must be broken off inside the outer bark and must leave an unsplintered broken end.

Branches and stubs of branches, removed with a saw, must be cut flush with the outer bark or slightly into the outer bark. The cut must not be into the cambium and no stubs left protruding beyond the bark surface. In pruning live branches, the cut will be made through the branch collar.

IV. Release

Release will consist of removing unmarked trees from around the marked trees to provide 3 feet of open space around their crowns.

Stumps may be any height up to 3 feet.

Tops will be felled away from the released tree and will be made to lie on the ground.

V. Disposal of Slash

Live branches removed in the pruning operation will be scattered so that none are within 4 feet of the base of the pruned tree. Trees cut in a release operation will be lopped so that no branches stand more than 2 feet above the ground.

Table 1 - Relative development of principal white pine competitors and suggestions for treatment in cleaning within blister rust control units

Species	Stand condition	Relative development and probable final composition of naturally grown stands	Suggested treatment
Western hemlock	Easterly, westerly, southerly and upper north slopes and flats with overhead shade less than 30 percent.	Hemlock will normally be outgrown by white pine. At maturity white pine will normally form the bulk of the dominant stand with hemlock largely as an understory.	Remove all hemlock as large or larger than the white pine for a distance of 4 to 6 feet from the better white pine saplings and remove all advance growth hemlock wherever found. If a good stocking of cedar is present, clean out hemlock to favor cedar as an understory in place of hemlock.
	All exposures, overhead shade more than 30 percent, except lower north slopes of any shade condition.	White pine will barely hold its own under shade of 30 to 40 percent and on open lower north slopes. Under heavy shade (about 40 percent or more) will be outgrown by the more tolerant hemlock. Without cultural treatment, hemlock will form an important part of the dominant stand, definitely crowding out white pine.	Do not clean stand unless most of overwood can be removed. Remove all hemlock more than two-thirds as tall as the white pines for a distance of 4 to 6 feet from the better white pine trees. If cedar is present, clean out hemlock to form cedar by cutting hemlock for a distance of about 2 feet around the better cedars.
Western redcedar	Any stand where it occurs.	Western redcedar is a very tolerant, shade-demanding, slow-growing, persistent species; it characteristically develops as an understory under less tolerant species. It will outgrow white pine only under dense shade.	Cedar should be encouraged wherever practicable. Where stands are too dense, cut cedar and hemlock for a distance of about 2 feet around the better cedar stems.
Grand fir	Any stand where it occurs.	Grand fir will nearly equal white pine growth on most sites and will outgrow it under shade and on lower north slopes. Without cultural treatment grand fir will usually form an important component of the final stand.	Remove all grand fir more than two-thirds as tall as white pine for a distance of 6 to 8 feet from the better white pine trees.
Douglas-fir	Any stand where it occurs.	Douglas-fir will about hold even with white pine during the early part of the life of the stand. During this period it is a serious competitor with white pine where it occurs. During the pole stage, Douglas-fir loses out in competition with white pine. It seldom is present in large numbers on good white pine sites.	Remove all Douglas-fir more than two-thirds as tall as white pine for a distance of 6 to 8 feet from the better white pine trees.
Western larch	No overhead shade, any stand where it occurs. Larch seldom of importance under shade.	Western larch is a very intolerant species. It has a very rapid initial growth rate and will strongly overtop white pine during the early years of development and a certain percentage will maintain its height advantage throughout the life of the stand.	Remove all larch for a distance of about 8 feet from the better white pine trees.
Lodgepole pine	No overhead shade, any stand where it occurs. Lodgepole pine seldom of importance under shade.	Lodgepole pine makes rapid growth in early life, usually developing into undesirable "wolf" trees in young white pine stands, and in this stage is a serious competitor of white pine. White pine will, however, outgrow lodgepole during the pole stage. Lodgepole never makes up an important component of older stands.	Remove all lodgepole for a distance of 6 to 8 feet from the better white pine trees.
Ponderosa pine	No overhead shade, any stand where it occurs. Ponderosa pine seldom of importance under shade.	Ponderosa pine is an intolerant, rapidly growing tree in early life. However, in the dense white pine stands it eventually loses out.	Remove ponderosa pine trees for a distance of 6 to 8 feet from the better white pine trees.
Engelmann spruce	Any stand where it occurs.	Engelmann spruce is a tolerant, relatively slow-growing tree. Rarely, except under shade, will it compete seriously with pine.	Remove all Engelmann spruce as tall or taller than white pine for a distance of 6 to 8 feet from the better white pine trees.

Table 2 - Relative development of principal ponderosa pine competition and suggestions for treatment in cleaning

Species	Stand condition	Relative development and probable final composition of naturally grown stands	Suggested treatment
Douglas-fir	Southerly exposures and flats.	With an equal start ponderosa pine will outgrow Douglas-fir except under moderate to dense shade. Unless shade conditions are favorable for Douglas-fir, ponderosa pine does well in holding its own and will make up a large proportion of the stand at maturity.	Where Douglas-fir is crowding or overtopping pine, remove all Douglas-fir as large or larger than pine for a distance of 6 feet from the better ponderosa pines.
	Northerly exposures.	Ponderosa pine is hard-pressed by Douglas-fir, especially under shade conditions. Ponderosa pine unlikely to make up a large proportion of the stand at maturity.	Do not clean stand unless most of overwood is removed. Remove all Douglas-fir more than two-thirds as tall as ponderosa pine for a distance of 6 feet from the better ponderosa pines.
Grand fir	Any exposure where it occurs.	With an equal start ponderosa pine will outgrow grand fir except under moderate to dense shade. Ponderosa pine is hard-pressed by grand fir under shade and where grand fir gains an advance start.	Where grand fir is crowding or overtopping ponderosa pine, remove all grand fir more than two-thirds as tall as ponderosa pine for a distance of 6 feet from the better pines. Do not clean unless overwood is largely removed.
Western larch	Any exposure where it occurs.	Western larch has much the same growth rate as ponderosa pine, is intolerant, but prefers more moist and cooler sites than does ponderosa pine.	Larch is a desirable species. Should not be cut unless the tree is of poor quality or form, except in "pure" ponderosa type stands on good site.
Lodgepole pine	Any exposure where it occurs.	Lodgepole pine has much the same initial growth rate as ponderosa pine. Ponderosa pine has a greater growth rate in the pole stage and attains a greater height than lodgepole pine. The two species are much the same in tolerance. Lodgepole crowds ponderosa where it gets an advance start.	Remove all lodgepole pine as large or larger than ponderosa pine for a distance of 6 feet from the better ponderosa pines. Cleaning may have to be two-stage to prevent excessive loss of ponderosa pine through snow breakage.
Engelmann spruce	Any stand where it occurs.	Engelmann spruce is a tolerant, relatively slow-growing species. It competes with ponderosa pine only under shade and where it gains an advance start.	Spruce is a desirable species. Seldom should it be cut unless it is of poor quality or form.
Alpine fir	Any stand where it occurs.	Alpine fir is a tolerant, relatively slow-growing species. It competes with ponderosa pine only under shade and where it gains an advance start.	Where alpine fir is overtopping ponderosa pine, remove all fir as large or larger than pine for a distance of 6 feet from the better pines.

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